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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

FEBRUARY 1923

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29 WEST 39TH STREET NEW YORK

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THE

JOURNAL
OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XII February, 1923 No. 2

Chronicle and Comment

Engineer and Salesman

THE engineer and the salesman ought to talk things over; they ought to have conferences and ride in machines together. There should be constant contact so that the engineer may know what problems develop as between the salesman and the customer.—George M. Graham.

The Meetings of 1923

THE attention of the members is directed to several important announcements in this issue of the JOURNAL relating to future meetings of the Society. A national meeting devoted to Automotive Transportation will be held at Cleveland in April. The location of the Summer Meeting will undoubtedly be in the East, probably at a seashore resort. The Production Meeting will be held at Cleveland during the month of October and will follow the plan that was so successful in Detroit last year. The technical sessions that have been a feature during the New York Show week are to be transferred to Detroit, in connection with the 1924 Annual Meeting. The reasons for these departures from precedent are given fully on p. 243; it is important that you be familiar with them.

Brake-Drum Standardization

TO determine the feasibility as well as the desirability of standardizing brake-drums, comments in reference to this question were recently solicited from passenger-car and motor-truck builders. Of the replies received, 33 companies were in favor of standardizing brake-drums as against 22 who were not in favor of such action. The objections to undertaking such standardization were based principally on the following reasons:

(1) The tendency toward the use of the 20-in. rim.
(2) The tendency toward the use of four-wheel brakes.
(3) The tendency toward the use of transmission brakes.
(4) The tendency toward the use of air and hydraulic brakes.
(5) The fact that brakes are not satisfactory as at present designed.

The comments have been sent to the members of the Axle and Wheels Division in abstracted form and will doubtless be of considerable aid in determining whether the standardization of brake-drums should be undertaken.

The Public Demands It

THERE is one group of people in this Country that favors the flat-rate service-system; they are the car-owners. Several men prominent in our industry have said that the car-owners are the real bosses of the automotive industry. If this be true, and logically it must be, then it is high time that flat-rate practice became universal. It is the Society's privilege to print in this issue of THE JOURNAL one of the most convincing and informative papers that has been written on modern service-systems. We refer to the paper by Don T. Hastings on p. 193. It is rather significant that the system outlined should have been devised and made practical by an engineer whose entire experience had been in the designing end of the business previous to his entering the service field. The forms, accounting methods and policies presented are the result of painstaking analysis, engineering analysis, and deserve the most careful reading, not alone by service-men, but by everyone having a sincere interest in the future of our industry and an appreciation of what the good-will of the car-owner means to designer, constructor and distributor alike. If the service or sales managers of your company do not receive THE JOURNAL, loan them this copy so that they may read Mr. Hasting's paper.

Differential Standardization

ON p. 229 of this issue will be found Chairman S. O. White's progress report on the work of the Differential Subdivision. That the work of this Subdivision is of real importance to every executive and engineer is well brought out in the following paragraphs quoted from a letter recently received from an executive well known to the industry.

> I can see no reason why a very satisfactory set of standards cannot be worked out, covering side gears, pinions and differential spiders, for both passenger-car and motor-truck axles. Such standardization is more important than the standardization of front-axle hubs because it would be more readily accepted by differential, axle and car manufacturers than would the stand-

ardization of hubs. Furthermore, it would result in a greater saving to the industry in general as there is absolutely no excuse for the large variation and the number of types of differential that are now being manufactured by the differential and axle manufacturers.

The recommendation of the Differential Subdivision was printed in full in the January issue of THE JOURNAL on p. 124. It is the desire of the Subdivision that users and manufacturers superimpose the proposed standard on their own axle designs on their drawing-board and from that base criticisms and suggestions which would be of assistance to the Subdivision in bringing the preliminary report into accord with the best present-day differential design.

The Industry

THE automotive industry within the space of its short manufacturing career has advanced until it is today third among the industries of the United States in value of annual output, affording annual employment to some 2,430,000 persons who earn their wage either in the output of the car itself or in producing the materials that go into the vehicle. About 600,000 are in the industry itself.

Today there are, in round numbers, 10,500,000 motor vehicles in the United States, or one to every 10 persons in the Country. The total world registration is but 12,500,000, so that it appears at once that 83 per cent of the cars now in use are in this Country. Of this total approximately 87 per cent are of American manufacture. No man can forecast fully the directions that the use of the motor vehicle will take. Each day finds some new place for it.

This development has brought in its wake new questions, or rather old questions demanding new answers. The advance in 10 years from 600,000 to 10,500,000 cars brings new requirements in methods, whether they be legislative, industrial or financial in nature. Only trained men can give us the key to their solution.

The motor vehicle has become a major unit in transportation, requiring minds of varied training in such fields as civil, chemical, mechanical, metallurgical and electrical engineering, economics, business administration and finance, research in physical and commercial lines and many other branches, including public service.

The industry will proceed rapidly or slowly according to the recognition that educators give to the magnitude of the educational need involved.—C. C. Hanch.

Highway Traffic

IN his last message to Congress, President Harding said that it may be expected that 20 years hence the population of this Country will be 150,000,000, or three times our recorded population in 1880. While, during the three decades ended in 1920, our population increased less than 30 per cent, the freight movement by railroad increased over 250 per cent. Our railroad mileage, which constitutes 40 per cent of that of the world, is inadequate for our present requirements.

The problem is enormous. In the words of our chief executive, we face transportation costs that much of the traffic cannot bear, and we must plan to coordinate all transportation facilities, turning the motor truck into a railroad feeder and distributor. The motor car must be applied to its most practical use. The demand for lowered costs on farm products and basic materials cannot be ignored.

With regard to highways and proportionate shares of expense in defraying the cost of their construction and maintenance, perhaps motor vehicles and related elements should pay more of the bill than they do at present, but they should not pay all of it. One idea is that they should bear the maintenance cost. What can and should be done varies with the locality.

When completed, highways belong to the public and not alone to those who use them. The case is different from that of the railroad, the roadbed and rights-of-way of which are corporately owned. The present conditions cannot be improved by undue taxation or regulation of motor vehicles. The capital cost of highways must be balanced with the saving in transportation cost to be had by operation of motor vehicles on them. Much more information is needed on costs of operation, including terminal expense. Adequate studies should be made of the effect of improved grades on highway vehicle efficiency. The whole aim of current highway research, in which the Society is cooperating, is economic regional conformity in the interest of the public. The public always eventually bears the expense of waste. Obviously, we cannot afford not to have a highway system that is commensurate in extent and quality with economic facts. The art and science of road-building have developed so that it is possible to determine the merit of subgrades, and unsatisfactory subgrade conditions can be cured, and should be cured in cases where it would not be less expensive to strengthen the road. There is definite information as to just what loads roads of different types will withstand. There is lack of knowledge as to what the maximum wheel-loads should be from the standpoint of economy. The problem is to fit the vehicle to the road, making the cost of operation a reasonable minimum. Transportation will be measured by its cost. The time is not far distant when there will be 20,000,000 motor vehicles on our roads. In the solution of the problems involved it is necessary that there be whole-hearted cooperation between the vehicle engineer and builder, the road builder, the State and Federal Government authorities and the public. It should be possible to state with considerable clearness what types of vehicle can be used most efficiently and economically in various kinds of hauling. The work to be done falls into two classes: (*a*) definite laboratory researches and (*b*) the securing of statistical data on engineering facts.

The Society of Automotive Engineers has pledged itself to participate aggressively and thoroughly in furthering the movement to this end, which has been definitely planned and launched after a conference of representatives, in addition to those of the Society, of the United States Bureau of Public Roads, the National Automobile Chamber of Commerce and the National Research Council. Let us not witness, in our day at least, the paralysis of transportation feared by President Harding.

THE 1923 ANNUAL MEETING

Will Be Found Described in This Issue of THE JOURNAL on p. 231

Economic Motor-Fuel Volatility

By R. E. CARLSON[1]

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND CHARTS

THE paper is a report covering an investigation made by the Bureau of Standards to secure data that can be used as a basis for estimating the effect of a change in gasoline volatility on the fuel-consumption of cars now in service throughout the United States. Actual tests began in August, 1922, to determine the effect of four fuels of different characteristics on the number of car-miles obtainable per gallon of fuel, as well as on crankcase-oil dilution.

Descriptions are given of the fuels used, the test-cars, the apparatus, the tests and the test methods, inclusive of the crankcase-oil dilution investigation, voluminous tabular data accompanying the text. Table 12 gives a summary of the results and these are discussed briefly. The program for a proposed similar investigation under low-temperature conditions is outlined.

THE continued growth of the automotive industry, with the consequent demand for fuel by the using public, has made the question of meeting this demand one of the most important economic considerations with which the Country is concerned. The question confronting the oil industry is how to meet the ever-increasing demand for fuel. Refinery methods have been the subject of much study, and continued improvement has increased the yield of gasoline from a given quantity of crude oil but, notwithstanding this progress on the part of the oil industry, there is still apparent the possibility of a wide gap between the quantity of gasoline required and the gasoline production from the available supply of crude oil.

A general discussion has been in progress, between the automotive and the oil industries, covering the demand on the part of the automotive industry for a fuel of certain characteristics and the ability of the oil industry to meet this demand.

The purpose for which this investigation was undertaken, by the Bureau of Standards in conjunction with the Society of Automotive Engineers, the American Petroleum Institute and the National Automobile Chamber of Commerce, was to secure data that could be used as a basis for estimating the effect of a change in gasoline volatility on the fuel-consumption of the cars now in service throughout the Country. If car-owners could, with equal satisfaction, use a less volatile fuel than the present grade and obtain approximately the same number of miles per gallon, the fuel-consumption would remain the same, while the gasoline production could be increased by at least 30 per cent, in case the heaviest of the four fuels tested in this investigation were used. This would represent a real economy to the average car-owner for the reason that this increased production would serve either to delay the tendency toward an increase in the price of gasoline, or at least to decrease its rate of rise. This is merely the operation of the law of supply and demand.

The cooperative feature of the investigation consisted of the furnishing of men and the loan of special equipment by the oil and the automotive industries through the American Petroleum Institute, the Society of Automotive Engineers and the National Automobile Chamber of Commerce, the Bureau assuming the responsibility for the actual carrying out of the work. Through this cooperation the oil and the automotive industries are at all times in close touch with the work, since their representatives are actually assisting in carrying it out in conjunction with the personnel of the Bureau. This cooperation familiarizes the representatives with Bureau facilities and procedure and, at the same time, the Bureau is benefited by a closer contact with the industry and the problems that confront it. The oil and the automotive industries have thus been brought more closely together in the working-out of a problem that affects, in a practical way, every user of gasoline-propelled equipment throughout the Country.

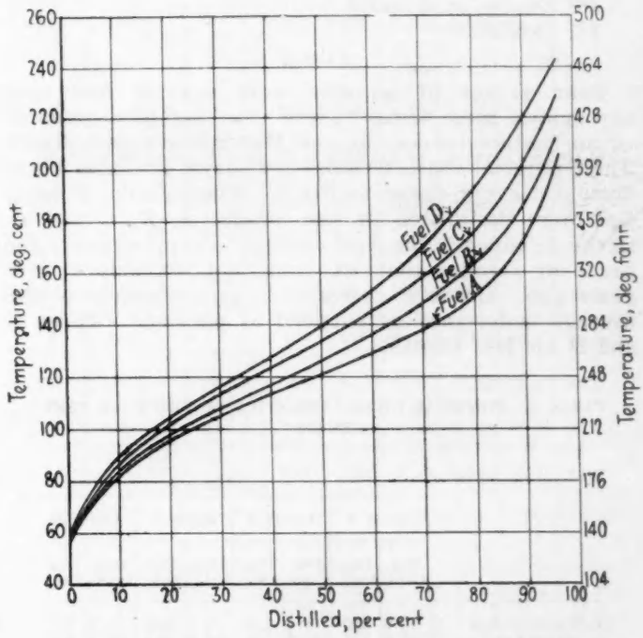


FIG. 1—DISTILLATION CURVES OF THE FOUR FUELS USED

The problems involved in this investigation have been discussed for the past year or two by those interested. As a result, a definite program of tests was formulated in the summer of 1922, and the Bureau was authorized to proceed. Actual tests were started in the first week of August. The program embraced a series of tests to determine the effect of four fuels of different characteristics on the number of miles per gallon obtainable as well as on crankcase-oil dilution. After a discussion of a report covering the work completed up to Oct. 1, 1922, the advisory committee decided that it would be desirable to continue the work under winter conditions. The continuation of the investigation under such conditions is now under way.

[1] Mechanical engineer, Bureau of Standards, City of Washington.

In this report, the results of the summer work will be presented, and the program for work under winter conditions discussed.

Investigation Under Summer Conditions

The summer work is covered in the following order:

(1) Fuels
(2) Cars
(3) Fuel-consumption tests
(4) Crankcase-oil dilution tests
(5) Results
(6) Discussion of results
(7) Conclusions

Fuels

Four grades of gasoline were selected and used throughout these tests. These were specially prepared by an Eastern refinery to meet the desired specifications. Their physical characteristics are shown in Table 1 and their distillation curves in Fig. 1. These grades of gasoline were designated by the letters, *A*, *B*, *C* and *D*. Grade *A*, which is the most volatile, is approximately the grade of gasoline that was generally available 4 or 5 years ago. Grade *B* corresponds approximately to the average motor-gasoline supplied at present. Grades *C* and *D* are less volatile.

TABLE 1—PHYSICAL CHARACTERISTICS OF THE FOUR TEST-FUELS

	Fuel							
	Grade *A*		Grade *B*		Grade *C*		Grade *D*	
	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.
Distillation, Initial	49.0	120	52.0	126	51.5	125	54.5	130
10 Per Cent	83.0	181	83.5	182	84.5	185	89.0	192
20 Per Cent	94.0	201	96.3	205	102.0	216	104.5	221
30 Per Cent	105.0	221	106.7	225	113.5	237	116.0	241
40 Per Cent	113.5	237	116.3	241	124.5	257	128.0	262
50 Per Cent	121.0	250	126.2	259	134.0	275	139.0	282
60 Per Cent	130.0	266	136.0	277	145.0	293	153.0	307
70 Per Cent	139.5	284	148.0	298	159.0	318	170.5	338
80 Per Cent	149.5	302	163.7	327	176.5	351	194.0	381
85 Per Cent	158.0	316	172.0	342	186.0	367	204.0	399
90 Per Cent	171.5	342	185.0	365	201.0	394	218.5	426
95 Per Cent	192.0	378	203.0	397	218.0	424	233.0	452
End, or High Point	206.5	403	214.0	417	229.5	446	244.5	472
Average Boiling-Point	121	250	125	257	135	275	142	288
Equilibrium Temperature[2]	151	304	163	325	176	349	192	378
Dew-Point, 12 to 1 Mixture[2]	11	52	31	88	47	117	67	153
Average Molecular Weight[2]	111.5		114.0		119.5		123.5	
Specific Gravity at 26 Deg.Cent.(78.5 Deg. Fahr)	0.727		0.733		0.736		0.740	
Index of Refinement, (26 deg. Cent.=78.5 Deg. Fahr.)	1.4110		1.4110		1.4150		1.4165	
Viscosity at 26 Deg. Cent. (78.5 Deg. Fahr.), centipoises	0.527		0.533		0.577		0.592	
Doctor Test	Sweet		Sweet		Sweet		Sweet	
Unsaturated Compounds, per cent	5.5		6.5		6.0		6.0	
Moisture Content	None		None		None		None	
Acidity	None		None		None		None	
Reaction Test	None		None		None		None	

[2] Wilson's Method.

Table 2 gives the possible production of these four fuels as estimated by several large refineries. On the basis of a 100 per cent production for Grade *B*, Grade *A* represents a decrease of approximately 12 per cent, Grade *C* an increase of approximately 13 per cent and Grade *D* an increase of approximately 30 per cent of gasoline from a given quantity of crude oil.

TABLE 2—ESTIMATED PRODUCTION OF FOUR TEST-FUELS, COMPARED WITH GRADE-*B* FUEL

Refiner	Fuel *A*	Fuel *B*	Fuel *C*	Fuel *D*
1	81	100	114	128
2	91	100	111	124
3	83	100	113	122
4	84	100	115	133
5	90	100	112	145
Average	86	100	113	130

Test Cars

Four makes of car were secured that were believed to represent approximately 75 per cent of the total number of cars now in use in the United States. The characteristics of these cars are given in Table 3. These cars are designated by the letters *W*, *X*, *Y* and *Z*. Considerable care was taken in the selection of each of these four cars, to obtain an average of each type so far as possible. The original equipment was left intact, and only sufficient overhauling and adjusting was done to insure having the cars remain in good condition during the test period.

TABLE 3—CHARACTERISTICS OF TEST-CARS USED

Car	*W*	*X*	*Y*	*Z*
Year	1920	1920	1920	1920
Number of Cylinders	6	4	4	4
Bore, in.	3⅜	3 11/16	3⅞	3¾
Stroke, in.	4½	4	4½	4
Piston Displacement, cu. in.	241.6	171.0	212.0	177.0
Power Rating[3], hp.	27.30	21.75	24.03	22.50
Wheelbase, in.	118	102	114	100
Weight, Including Equipment and Crew, lb.	3,760	2,450	3,210	2,335
Tires, in.	33x4	30x3½	32x3½	30x3½
Gear-Ratio	4.000	3.670	4.166	3.630
Miles Run, Approximate	15,000	10,000	15,000	12,000

[3] Based on the National Chamber of Commerce formula.

Fuel-Consumption Tests

A comparison of the number of miles per gallon obtained with different fuels in a given car should be based on a measurement of the quantity of fuel consumed when the same number of foot-pounds of energy is delivered by the engine per mile under a specified schedule of speeds, either constant or changing, and when the operating conditions, such as the carbureter adjustment, the temperatures and the speed, are the same or are particularly adjusted to each fuel. If a car were towed around a definite course following a given schedule of speed-changes and the results of a measurement of the pounds pull on a drawbar dynamometer at each instant plotted against distance traveled, the area under the curve would represent the number of foot-pounds of work done in towing the car over the course. If the run were repeated and the wind, the road surface, the lubricant temperature, the car weight and the tire pressure remained the same, the same curve would be obtained. If the car were driven by its engine through the same series of operations, the energy output of the engine would be identical with that previously registered by the dynamometer. If several runs were made within a short time, the changes in the wind, the lubricant temperature and the tire pressure would not change sufficiently to affect the number of foot-pounds of energy output materially. If two suc-

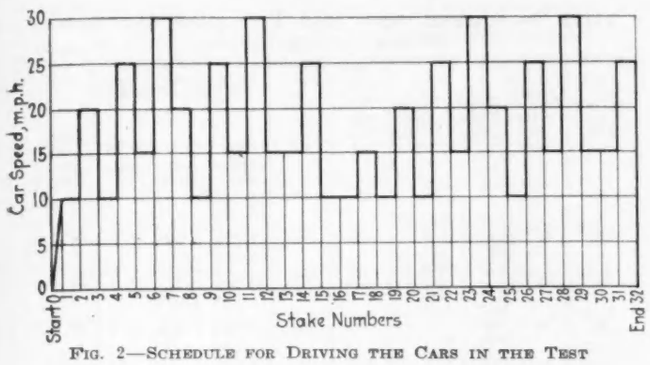


FIG. 2—SCHEDULE FOR DRIVING THE CARS IN THE TEST

cessive runs were made following identically the same schedule, but when two different fuels were supplied to the engine, the ratio of the quantities of fuel used in the two runs would represent the ratio of the number of miles per gallon to be expected from the two fuels when used in that car under the conditions of driving obtaining in the run.

In these tests, three successive runs were made on one fuel, before changing to a second, with which three more successive runs, were made. By means of the sets of three successive runs a constant check was obtained on the constancy of the energy output. To increase the reliability of the results, at least two such independent comparisons were made. The fuels were compared with each other by comparing, independently, Grades *A*, *C* and *D* with Grade *B*, or the reference fuel. It was found that the set of six runs used in each comparison could be made in from 2 to 3 hr, and no material variation in energy output was anticipated in this time.

The driving schedule used in these tests is shown schematically in Fig. 2. The maximum speed was limited by traffic regulations but the range of speed, acceleration and deceleration was estimated to be that usually encountered in ordinary driving. All accelerations were made with wide-open throttle, and decelerations with fully closed throttle and without the use of brakes. These two arbitrary conditions of driving operation were imposed to obtain more reproducible handling of the throttle and to eliminate the uncertainty of varying use of the brakes.

TABLE 4—SUMMER TESTS, CAR *W*; SAME CARBURETER SETTING FOR ALL FUELS

Grade of Fuel	Carbureter Setting	Total Time, Sec.	Total Fuel Used CC.	Average Time, Sec.	Average Fuel, CC.	Fuel-Consumption: CC. per Sec.	Gal. per Hr.	Miles per Gal.	Ton-Miles per Gal.
B	4.4	735.4 738.4 746.7	643.9 642.8 633.2	740	640	0.865	0.822	19.1	35.8
C	4.4	746.6 740.4 735.8	645.2 650.9 646.5	741	648	0.874	0.831	18.8	35.4
B	4.4	731.0 739.7 740.6	644.3 641.7 642.1	737	643	0.873	0.830	19.0	35.7
C	4.4	738.4 759.0 755.0	640.4 634.3 634.1	751	636	0.848	0.806	19.1	35.9
B	4.4	722.3 724.2 717.2	645.4 659.5 639.0	721	648	0.899	0.854	18.8	35.4
A	4.4	719.8 724.3 725.1	664.8 651.7 651.9	723	656	0.908	0.864	18.6	34.9
B	4.4	719.3 734.7 732.3	649.7 640.7 643.4	729	645	0.884	0.841	18.9	35.5
A	4.4	734.6 728.6 647.7[a]	647.3 639.5 567.1	732[b]	643[b]	0.878[c]	0.835[c]	19.1[c]	35.9[c]
B	4.4	725.5 726.6 734.7	645.7 655.1 650.3	729	653	0.896	0.852	18.7	35.1
D	4.4	735.1 736.5 737.4	646.3 625.6 641.6	736	638	0.866	0.823	19.1	35.9
B	4.4	742.3 739.0 743.1	650.3 642.6 632.7	742	642	0.866	0.823	19.0	35.7
D	4.4	749.2 739.7 746.8	645.6 638.1 621.6	745	635	0.854	0.812	19.2	36.1
General Averages									
B	4.4	.....	.....	739	641	0.869	0.826	19.0	35.7
C	4.4	.....	.....	745	642	0.861	0.818	19.0	35.7
B	4.4	.....	.....	725	646	0.892	0.848	18.9	35.4
A	4.4	.....	.....	727	650	0.893	0.850	18.8	35.4
B	4.4	.....	.....	735	648	0.881	0.838	18.9	35.4
D	4.4	.....	.....	741	637	0.860	0.818	19.1	36.0

[a] Watch stopped just after passing stake No. 29.
[b] Average of two runs.
[c] Average of three runs.

TABLE 5—SUMMER TESTS, CAR *W*; CHANGED CARBURETER SETTING FOR EACH FUEL

Grade of Fuel	Carbureter Setting	Total Time, Sec.	Total Fuel Used, CC.	Average Time, Sec.	Average Fuel, CC.	Fuel-Consumption: CC. per Sec.	Gal. per Hr.	Miles per Gal.	Ton-Miles per Gal.
B	4.40	724.7 725.1 730.7	648.4 634.3 608.6	727	630	0.868	0.826	19.3	36.3
A	5.00	726.9 717.0 724.6	599.3 595.6 594 1	723	596	0.825	0.785	20.4	38.4
B	4.40	717.2 724.8 726.4	624.9 624.4 624.1	723	625	0.866	0.824	19.5	36.7
A	5.00	741.0 735.1 724.8	591.7 592.4 592.7	734	592	0.808	0.768	20.6	38.7
B	4.40	713.0 711.5 717.0	663.0 653.5 657.1	714	658	0.922	0.877	18.5	34.8
D	3.75	713.0 716.2 710.5	674.9 676.4 668.3	713	673	0.944	0.898	18.1	34.1
B	4.40	710.0 713.4 719.3	632.5 623.5 616.2	714	624	0.874	0.831	19.5	36.7
D	3.75	721.2 717.0 715.0	664.9 657.9 670.0	718	664	0.926	0.881	18.4	34.5
B	4.40	723.5 717.0 717.6	634.4 639.4 640.0	719	638	0.886	0.884	19.1	35.8
C	4.00	723.4 715.2 718.0	679.2 670.8 662.6	719	671	0.933	0.887	18.1	34.1
B	4.40	719.1 712.8 719.8	648.1 638.2 625.5	717	637	0.888	0.845	19.1	35.8
C	4.00	727.2 726.0 719.8	654.1 661.6 657.8	724	658	0.906	0.862	18.5	34.8
General Averages									
B	4.40	.....	.....	725	627	0.867	0.823	19.4	36.5
A	5.00	.....	.....	728	596	0.817	0.776	20.5	38.5
B	4.40	.....	.....	714	643	0.898	0.854	19.0	35.7
D	3.75	.....	.....	716	670	0.935	0.890	18.2	34.3
B	4.40	.....	.....	718	638	0.887	0.845	19.1	35.8
C	4.00	.....	.....	722	664	0.920	0.875	18.3	34.5

The driving schedule used in these tests is shown schematically in Fig. 2. The maximum speed was limited by traffic regulations but the range of speed, acceleration and deceleration was estimated to be that usually encountered in ordinary driving. All accelerations were made with wide-open throttle, and decelerations with fully closed throttle and without the use of brakes. These two arbitrary conditions of driving operation were imposed to obtain more reproducible handling of the throttle and to eliminate the uncertainty of varying use of the brakes.

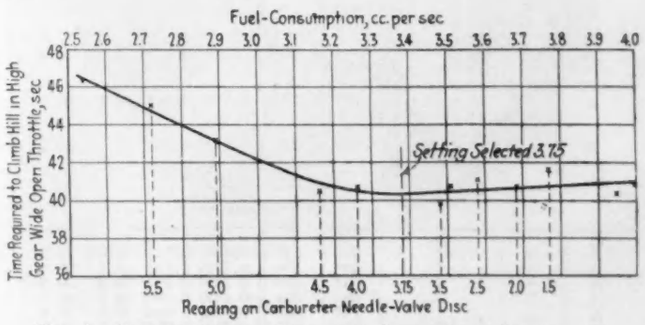

Fuel-Consumption, cc. per sec
Time Required to Climb Hill in High Gear Wide Open Throttle, sec
Setting Selected 3.75
Reading on Carbureter Needle-Valve Disc

FIG. 3—CHART SHOWING HOW THE CARBURETER SETTING FOR MAXIMUM POWER WAS DETERMINED

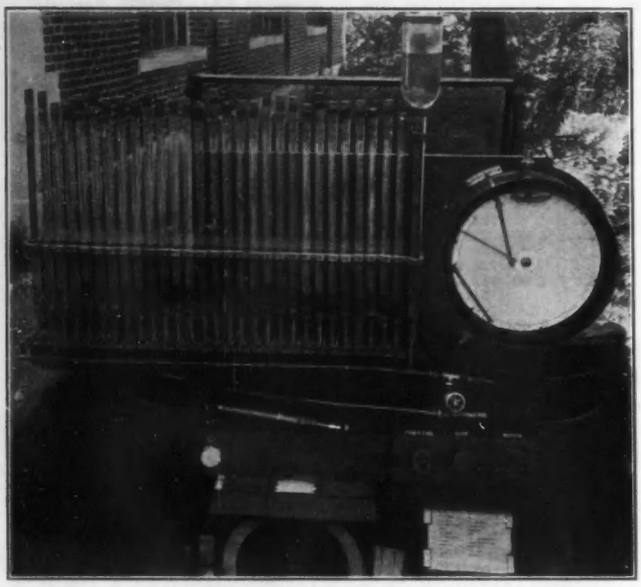


FIG. 4—APPARATUS EMPLOYED TO MEASURE THE FUEL, THE CAR SPEED, THE MANIFOLD DEPRESSION AND THE TEMPERATURE

The test-course selected is located in Potomac Park, City of Washington, and is known locally as the Speedway. The road is of asphalt, is in good condition and is practically flat. The course is 3.2 miles long. For the purpose of this work, it was divided into 32 sections,

TABLE 6—SUMMER TESTS, CAR *X*; FIXED-JET CARBURETER-SETTING

Grade of Fuel	Carbureter Setting	Total Time, Sec.	Total Fuel Used, CC.	Average Time, Sec.	Average Fuel, CC.	Fuel-Consumption: CC. per Sec.	Gal. per Hr.	Miles per Gal.	Ton-Miles per Gal.
B	Fixed Jet	710.4	526.8	713	527	0.739	0.703	23.1	29.2
		711.4	523.8						
		716.4	529.4						
C		705.4	522.4	705	532	0.755	0.718	22.9	28.9
		709.8	536.6						
		699.0	537.8						
B		703.4	545.5	703	547	0.777	0.739	22.3	28.1
		706.9	550.4						
		698.6	543.7						
C		689.0	543.5	688	543	0.789	0.751	22.4	28.3
		676.0	546.3						
		699.6	540.5						
B		689.8	504.2	687	500	0.729	0.694	24.4	30.7
		687.0	497.8						
		683.2	498.9						
A		689.2	513.9	688	510	0.743	0.707	23.9	30.1
		693.5	513.9						
		680.0	503.3						
B		682.8	496.5	681	497	0.729	0.694	24.5	30.9
		685.1	498.5						
		676.4	495.7						
A		687.3	509.2	682	506	0.741	0.705	24.1	30.4
		682.0	507.2						
		677.1	500.3						
B		715.0	514.1	719	518	0.721	0.686	23.5	29.6
		727.6	518.0						
		712.8	522.2						
D		715.0	495.5	714	504	0.706	0.671	24.2	30.5
		713.0	505.1						
		712.8	511.0						
B		712.5	520.7	711	519	0.730	0.694	23.5	29.6
		709.0	514.3						
		711.4	522.4						
D		707.5	501.6	710	509	0.717	0.681	24.0	30.2
		712.8	512.5						
		710.9	511.9						
General Averages									
B	Fixed Jet	.....	.....	708	537	0.758	0.721	22.7	28.7
C		.....	.....	696	538	0.772	0.735	22.7	28.6
B		.....	.....	684	499	0.729	0.694	24.4	30.8
A		.....	.....	685	508	0.742	0.706	24.0	30.3
B		.....	.....	715	519	0.726	0.690	23.5	29.6
D		.....	.....	712	506	0.711	0.676	24.1	30.3

TABLE 7—SUMMER TESTS, CAR *Y*; SAME CARBURETER SETTING FOR ALL FUELS

Grade of Fuel	Carbureter Setting	Total Time, Sec.	Total Fuel Used, CC.	Average Time, Sec.	Average Fuel, CC.	Fuel-Consumption: CC. per Sec.	Gal. per Hr.	Miles per Gal.	Ton-Miles per Gal.
B	55	677.3	655.6	675	646	0.956	0.909	18.9	30.3
		671.8	650.0						
		677.2	631.9						
A	55	672.3	661.1	675	670	0.988	0.939	18.3	29.3
		675.0	665.7						
		677.3	673.9						
B	55	667.3	637.2	670	643	0.960	0.913	18.9	30.4
		667.9	649.8						
		664.6	641.6						
A	55	667.0	669.5	666	670	1.005	0.956	18.2	29.2
		666.8	665.9						
		665.2	673.7						
B	55	680.4	652.6	674	650	0.974	0.926	18.8	30.1
		667.8	646.7						
		590.4[d]	587.6						
C	55	676.6	639.9	671	633	0.944	0.897	19.3	31.0
		670.6	636.1						
		665.7	622.2						
B	55	682.0	645.9	673	644	0.958	0.911	18.9	30.4
		668.6	639.5						
		669.4	647.3						
C	55	674.4	619.8	672	614	0.914	0.869	19.8	31.9
		672.9	611.9						
		668.6	610.2						
B	55	667.0	652.6	664	652	0.982	0.934	18.7	30.1
		662.8	659.1						
		661.6	642.9						
D	55	657.4	622.6	661	611	0.925	0.880	19.9	32.0
		661.6	609.8						
		663.3	601.4						
B	55	660.9	648.3	664	652	0.983	0.935	18.7	30.0
		669.8	660.7						
		660.0	647.0						
D	55	670.1	630.9	668	619	0.926	0.880	19.7	31.6
		664.7	611.1						
		669.9	613.7						
General Averages									
B	55	.....	.....	673	644	0.958	0.911	18.9	30.3
A	55	.....	.....	671	670	0.997	0.948	18.2	29.3
B	55	.....	.....	674	647	0.966	0.916	18.8	30.2
C	55	.....	.....	672	623	0.928	0.883	19.6	31.4
B	55	.....	.....	664	652	0.983	0.935	18.7	30.0
D	55	.....	.....	665	615	0.925	0.880	19.8	31.8

[d] Throttle valve-rod jumped out of throttle valve-lever just after passing stake No. 29.

FIG. 5—THE FUEL-SUPPLY TANKS AND THE DRIVER'S SPEEDOMETER

TABLE 8—SUMMER TESTS, CAR *Y*; CHANGED CARBURETER SETTING FOR EACH FUEL

Grade of Fuel	Carbureter Setting	Total Time, Sec.	Total Fuel Used, CC.	Average Time, Sec.	Average Fuel, CC.	Fuel-Consumption			
						CC. per Sec.	Gal. per Hr.	Miles per Gal.	Ton-Miles per Gal.
B	55	671.1 662.6 661.4	665.7 659.2 658.4	665	661	0.994	0.946	18.4	29.6
A	85	665.8 665.9 664.8	621.9 614.2 604.6	665	647	0.972	0.924	18.8	30.3
B	55	669.3 674.3 670.6	663.4 662.5 671.2	671	666	0.991	0.943	18.3	29.4
A	85	678.5 678.3 681.0	646.1 637.4 644.4	679	643	0.946	0.900	18.9	30.5
B	55	660.3 668.3 660.5	648.4 649.6 650.6	663	650	0.980	0.932	18.8	30.1
C	45	658.7 656.6 665.6	641.1 650.0 627.6	660	636	0.964	0.917	19.1	30.8
B	55	667.8 660.6 666.3	654.9 658.2 647.3	665	654	0.983	0.935	18.6	29.9
C	45	666.4 666.0 659.6	636.6 654.5 630.1	663	640	0.966	0.919	19.0	30.6
B	55	671.9 670.1 668.6	626.3 621.1 625.8	670	624	0.932	0.887	19.5	31.3
D	30	663.0 670.7 669.8	624.9 629.2 639.8	668	635	0.951	0.905	19.2	30.8
B	55	666.3 665.7 659.7	647.4 634.0 629.0	664	637	0.960	0.913	19.1	30.7
D	30	662.7 662.7 670.0	642.1 631.1 629.8	665	634	0.954	0.908	19.2	30.8
General Averages									
B	55	.....	.....	668	663	0.992	0.944	18.4	29.5
A	85	.....	.....	672	645	0.964	0.912	18.9	30.4
B	55	.....	.....	664	651	0.981	0.933	18.7	30.0
C	45	.....	.....	662	638	0.965	0.918	19.1	30.7
B	55	.....	.....	667	631	0.946	0.900	19.3	31.5
D	30	.....	.....	667	634	0.953	0.906	19.2	30.8

each section being 0.1 mile in length and marked by a sign-post on which driving instructions were indicated. The same operations were repeated on the two sides of the course, which are approximately parallel, so as to minimize the effect of wind on the accuracy of the results.

In the case of all the cars, except car *X*, which has a fixed-jet type of carbureter, two series of comparisons were made. One series was made with all the fuels, using the optimum adjustment for Grade-*B* fuel; the second series was made with the respective optimum settings for the fuels. The carbureter setting for each fuel was obtained by driving in high-gear up a given hill, and measuring the time required to make the ascent, as well as the amount of gasoline consumed. These runs were made over the range from a very lean to a very rich setting, and for the four fuels used. From these results, the gasoline consumption was plotted against the time of ascent and, from the curve for each fuel, the leanest setting giving the minimum time of ascent was selected, as illustrated by Fig. 3 for car *W*. In the case of two of the cars the carbureter settings were made by factory engineers; these agreed exactly with the settings obtained from the hill-test. An analysis of the exhaust-gas obtained from this setting indicated a mixture-ratio of approximately 12 lb. of air per lb. of fuel. The use of a materially leaner carbureter setting gave unsatisfactory results during the accelerations made on the Speedway test-course, which averaged from 1½ to 2 m.p.h. per sec.

The apparatus used in these tests is shown in Figs. 4, 5 and 6. The fuel-measuring system shown in Fig. 4 consisted of 32 burettes, each of 50-cc. capacity, and having the zero at the top. Each burette was provided at the bottom with a rubber tube and cut-off cock of such design that a single movement of the actuating lever closed one burette and opened the adjoining one. Gasoline was drawn from a given burette for each section of the course, this being opened at the beginning of the section when the stake was passed and closed at the end when the next stake was passed. Each burette therefore indicated the fuel consumed while passing over a given section of the course, under prescribed driving conditions such as acceleration, constant speed or deceleration. When the car had traversed the entire course, the burette readings were recorded, and their sum gave the total fuel-consumption for the circuit of the course.

Two separate fuel-tanks were used one to hold the Grade-*B* or reference fuel, and the other the fuel under test. These tanks are shown in Fig. 5. An air-pump was used to force the fuel from these tanks up to the glass reservoir shown at the right in Fig. 4. Before starting each run, the burettes were filled up to their zero-marks from this reservoir. When it was desired to change fuel, the valve in this line was opened and permitted all of the fuel in the burettes and the reservoir to be drained back into the proper tank. The line from the burettes to the carbureter was emptied of fuel by running the engine. The end of the test-course is some distance from the start, and changing fuels at the end insured running on new fuel by the time the car had reached the starting-point.

A graphic record of car-speed changes during the progress of a run was obtained by connecting a pen movement to a Van Sicklen chronometric tachometer, and mounting them on the recording vacuum gage used to record the manifold depression. Fig. 6 shows the ar-

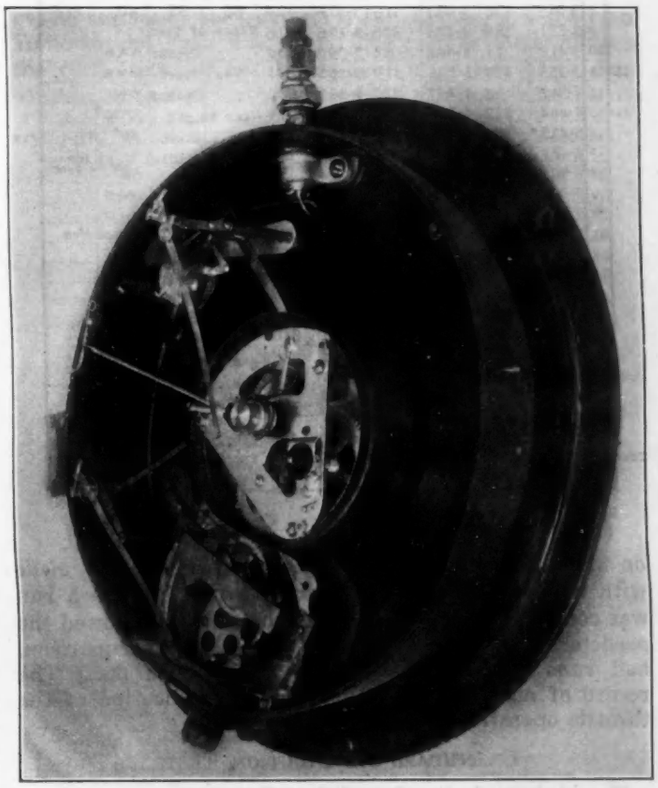


FIG. 6—ARRANGEMENT OF THE CAR-SPEED AND MANIFOLD-DEPRESSION RECORDER

rangement of the instrument used to give the combined record of car speed and manifold depression.

The temperatures of the outlet water and of the lubricant in the crankcase and the differential were determined by distance-type indicating-thermometers. The air temperatures were indicated by a mercurial thermometer.

Both the time required to pass over each section of the course and the time of a complete circuit were obtained by split-second stop-watches of the double-sweep type. These stop-watches were checked a number of times by the time section of the Bureau to determine their accuracy.

Fig. 7 shows a typical record-sheet. It will be noted that the temperatures were recorded at the beginning and the end of each run. The sheet also gives the tire pressures at the start and at the end of each test. The relative humidity and the barometric pressures as recorded were obtained from the United States Weather Bureau.

A combined manifold-depression and car-speed record, like that shown by Fig. 8, was obtained for each run. The record of the car-speed change is shown by the graph

Cooperative Fuel Research
COMPUTATION SHEET

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS

Test No. 4 Car "Y" Tach No. 4 Date 8-17 22
Time . . Fuel D. Carb. Sett .55 Burette No. . .

Run Number	Run Time	No. 1 cc used	Run Time	No. 2 cc used	Run Time	No. 3 cc used	Temperatures: Water	Diff	Crank Case	Air	
St. 0	8.7	4.4	9.7	6.6	9.5	9.4		Run No. 1			
1	44.7	17.2	44.7	15.6	44.5	16.1	68	26	31.5	19.5	St.
2	1-04.5	26.0	1-04.5	24.8	1-04.3	24.6	65	32	39	20.5	Stp.
3	1-32.8	11.8	1-31.5	9.6	1-31.0	11.9		Run No. 2			
4	1-50.0	29.6	1-49.1	30.7	1-48.3	30.4	62	30.5	37	20.3	St.
5	2-09.4	10.7	2-09.0	8.8	2-07.5	10.2	67	34.5	40	21.2	Stp.
6	2-23.6	38.8	2-22.8	37.0	2-21.7	37.9		Run No. 3			
7	2-38.0	5.6	2-38.5	8.8	2-36.5	6.2	62	31	38.5	20.9	St.
8	3-04.9	10.6	3-05.3	11.6	3-02.6	10.4	66	35	40	21.6	Stp.
9	3-22.1	33.9	3-22.3	32.6	3-19.6	31.6	Place of Test				
10	3-41.2	7.1	3-40.8	8.2	3-39.0	8.0		Driver	G.A.B.		
11-12	3-55.3	37.7	3-55.3	37.9	3-53.5	38.1	Crew	Observ.	H.M.R.		
13	4-34.2	19.8	4-34.7	22.0	4-33.6	20.8		Record.	E.W.E.		
14-15	4-49.4	27.2	4-50.3	26.5	4-49.2	27.1	Car Weight		3200*		
16	5-43.5	25.1	5-45.5	23.9	5-44.0	23.6	Tire Press.	Start	65*	Type Tires	
17	6-08.1	20.6	6-10.4	20.0	6-07.8	19.4		Middle	—	U.S. ROYAL CORD	
18	6-40.8	15.8	6-42.2	14.9	6-40.4	15.3		Stop	68*		
19	7-00.5	24.3	7-01.8	24.9	6-59.7	25.0	Barom.	Start	762.5		
20	7-28.7	13.1	7-28.2	12.0	7-28.0	11.8		Stop	761.0		
21	7-45.8	32.0	7-45.5	31.4	7-45.2	36.7	Oil Used		VEEDOL	Med.	
22	8-05.1	8.8	8-05.3	9.7	8-05.2	9.4	Rel. Humidity		61		
23	8-19.6	43.6	8-19.6	42.5	8-19.7	39.6	Wind	Direct.	SW		
24	8-34.7	7.6	8-35.1	8.6	8-35.0	7.8		Veloc.	5.14		
25	9-02.1	12.1	9-01.6	11.6	9-01.8	10.7	Weath.	AM	FAIR		
26	9-19.2	31.2	9-19.3	32.4	9-18.9	34.0		PM	FAIR		
27	9-39.5	9.0	9-38.8	9.5	9-38.2	7.8	Ave Time		670.2		
28-29	9-54.5	39.5	9-53.6	41.5	9-52.8	40.1	Ave cc		624.4		
30	10-35.7	22.9	10-34.0	19.5	10-33.8	21.9	Ave cc/sec		.932		
31	10-51.5	29.0	10-50.2	28.7	10-49.5	30.2	Gal/Hour		.886		
32	11-11.9	11.3	11-10.1	9.3	11-08.6	9.8	Mi/Gal.		19.5		
Totals	671.9	626.3	670.1	621.1	668.6	625.8	T Mi/Gal		31.3		
							General Remarks *over.				

Fig. 7—A Typical Sheet of One of the Tests

on which is marked the car speed. A template was made with which the car-speed record obtained from each run was compared to see how closely the car had followed the predetermined running-schedule. By this comparison, bad runs were easily detected and thrown out. The record of manifold depression gave an indication of the throttle operation by the car driver.

Crankcase-Oil Dilution Tests

To obtain an indication of the effect of these four fuels on crankcase-oil dilution, two cars, namely *Y* and *Z*,

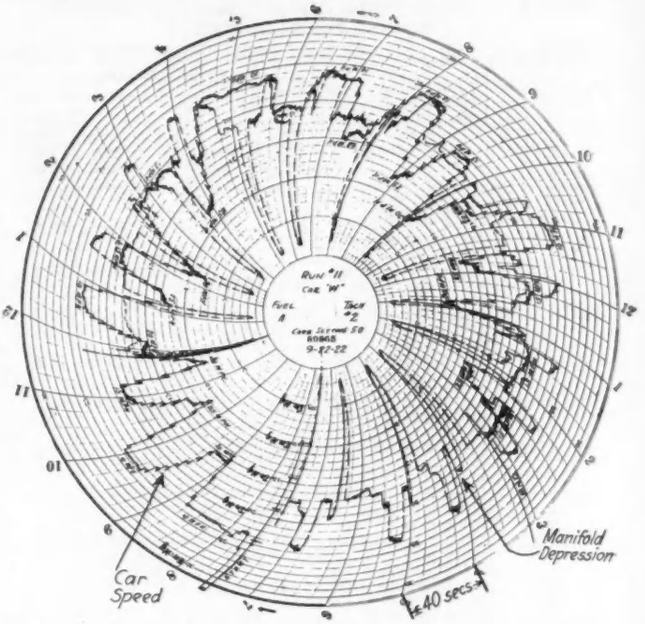


Fig. 8—Chart Obtained from the Car-Speed and Manifold-Depression Recorder

were driven between the City of Washington and Frederick, Md. This road is in fairly good condition and includes a relatively large number of hills. An average

TABLE 9—SUMMER TESTS, CAR *Z*; CARBURETER SETTING SAME FOR ALL FUELS

Grade of Fuel	Carbureter Setting	Total Time, Sec.	Total Fuel Used CC.	Average Time, Sec.	Average Fuel, CC.	Fuel-Consumption: CC. per Sec.	Gal. per Hr.	Miles per Gal.	Ton-Miles per Gal.
B	7.0	685.4 681.0 685.8	553.6 558.3 552.8	684	555	0.811	0.772	22.0	25.6
A	7.0	675.6 678.0 666.5	571.7 561.8 555.5	673	563	0.836	0.795	21.6	25.3
B	7.0	689.5 681.0 676.4	563.7 565.0 559.2	682	563	0.824	0.784	21.7	25.3
A	7.0	681.0 678.1 678.4	581.4 577.5 584.3	679	581	0.855	0.813	21.0	24.5
B	7.0	680.5 680.0 677.0	564.0 555.8 522.0	679	557	0.821	0.781	21.9	25.5
C	7.0	679.6 673.6 679.3	538.4 539.6 551.4	678	543	0.802	0.763	22.4	26.2
B	7.0	671.0 675.5 673.8	556.8 554.6 560.6	673	557	0.828	0.788	21.9	25.5
C	7.0	681.2 673.5 675.3	559.0 555.0 514.8	677	543	0.802	0.763	22.4	26.2
B	7.0	673.7 673.4 667.8	555.9 557.6 558.5	671	557	0.830	0.789	21.9	22.5
D	7.0	667.0 666.2 669.7	537.2 545.4 536.5	668	540	0.808	0.768	22.6	26.4
B	7.0	667.4 659.2 658.8	548.6 542.7 541.1	662	544	0.823	0.782	22.4	26.1
D	7.0	670.8 677.7 667.3	542.0 540.7 540.0	672	541	0.805	0.766	22.5	26.3

General Averages

B	7.0	.....	.....	683	559	0.818	0.778	21.8	25.5
A	7.0	.....	.....	676	572	0.846	0.804	20.3	24.9
B	7.0	.....	.....	676	557	0.825	0.784	21.9	25.5
C	7.0	.....	.....	677	543	0.802	0.763	22.4	26.2
B	7.0	.....	.....	667	551	0.827	0.786	22.1	25.8
D	7.0	.....	.....	670	540	0.808	0.767	22.6	26.3

TABLE 10—SUMMER TESTS, CAR *Z*; CHANGED CARBURETER SETTING FOR EACH FUEL

Grade of Fuel	Carbureter Setting	Total Time, Sec.	Total Fuel Used, CC.	Average Time, Sec.	Average Fuel, CC.	Fuel-Consumption CC. per Sec.	Gal. per Hr.	Miles per Gal.	Ton-Miles per Gal.
B	7.0	674.3 672.2 666.3	532.2 525.2 534.9	670	531	0.793	0.754	23.0	26.8
A	7.1	668.6 667.9 666.2	538.8 538.5 536.6	668	531	0.798	0.759	22.9	26.7
B	7.0	671.4 667.2 667.9	543.1 545.2 547.2	669	545	0.815	0.775	22.4	26.1
A	7.1	670.7 670.0 672.2	527.8 533.8 531.7	671	531	0.792	0.753	22.9	26.7
B	7.0	673.4 665.3 664.8	540.6 542.7 535.5	669	539	0.808	0.768	22.6	26.4
C	6.4	669.8 670.0 667.0	550.9 546.5 549.0	670	549	0.821	0.781	22.2	25.9
B	7.0	667.3 664.8 664.5	539.0 536.3 523.8	666	533	0.801	0.762	22.9	26.7
C	6.4	661.5 669.4 665.8	535.4 538.5 547.3	666	540	0.812	0.773	22.6	26.3
B	7.0	664.0 672.7 667.4	537.1 537.0 525.4	668	530	0.798	0.759	22.7	26.5
D	6.3	666.2 663.8 658.5	534.8 548.8 557.2	663	547	0.743	0.707	22.3	26.0
B	7.0	663.8 662.2 658.5	534.8 526.7 536.3	662	533	0.823	0.783	22.9	26.8
D	6.3	661.3 664.6 665.5	550.2 550.8 553.5	664	552	0.831	0.698	22.2	25.9
General Averages									
B	7.0	.....	.....	670	538	0.804	0.765	22.7	26.5
A	7.1	.....	.....	669	531	0.795	0.756	22.9	26.7
B	7.0	.....	.....	667	536	0.805	0.765	22.7	26.6
C	6.4	.....	.....	666	545	0.817	0.777	22.4	26.1
B	7.0	.....	.....	665	533	0.810	0.770	22.8	26.6
D	6.3	.....	.....	663	549	0.790	0.702	22.3	26.0

speed of 25 m.p.h. was maintained; this speed was checked by having the time of arrival and departure recorded at intermediate points between Washington and Frederick.

Two round-trips, representing a total of 200 miles, were made for each fuel. Before the start of the run on each fuel, the crankcase was drained, new oil put in and the engine run for from 5 to 10 min. This oil was then drained out and the crankcase filled with new oil. No oil was added during the 200-mile run. After each 50 miles, 8-oz. samples were taken and these were tested for the percentage of dilution and change in the viscosity. The figures given for the percentage of dilution were obtained by subtracting the percentage distilled off from the unused oil up to 300 deg. cent., (572 deg. fahr.) from the percentage distilled off from the used oil up to the same temperature.

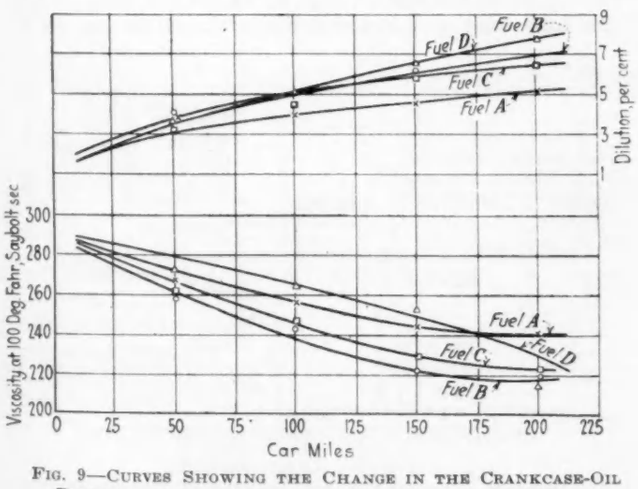


FIG. 9—CURVES SHOWING THE CHANGE IN THE CRANKCASE-OIL DILUTION AND THE VISCOSITY IN THE SUMMER ROAD TESTS

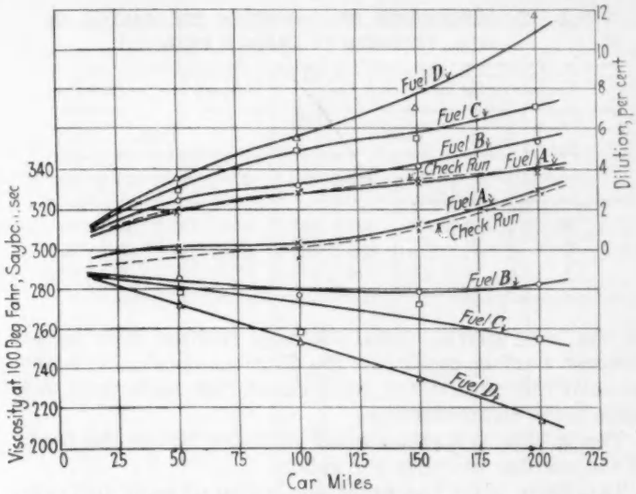


FIG. 10—A SIMILAR SET OF CURVES OBTAINED FROM A DIFFERENT CAR

DISCUSSION OF RESULTS

The results obtained from the summer work on the Speedway course are given in Tables 4 to 10 inclusive. It will be noted from the data that the fuel-consumptions obtained from three successive runs on any one fuel generally agree within 3 per cent, and it is estimated that the general averages are reliable within 2 per cent.

The results of the road tests for dilution are shown in Table 11 and Figs. 9 and 10. The results obtained from the road tests for crankcase-oil dilution are of interest as indicating a probable increase in dilution with the use

TABLE 11—SUMMER ROAD-TESTS FOR CRANKCASE-OIL DILUTION

Miles Run	Car *Y* 50	Car *Y* 100	Car *Y* 150	Car *Y* 200	Car *Z* 50	Car *Z* 100	Car *Z* 150	Car *Z* 200
Grade *A* Fuel								
Viscosity[a]	265	256	244	242	303	311	312	331
Dilution, per cent	2.8	3.0	3.5	4.1	2.0	3.0	3.4	4.2
Grade *A* Fuel								
Viscosity[a]	.....	.....	.....	.....	301	295	312	328
Dilution, per cent	.....	.....	.....	.....	2.0	3.0	3.3	3.8
Grade *B* Fuel								
Viscosity[a]	258	244	238[e]	236	.....	.....	.....	.....
Dilution, per cent	3.0	4.0	4.3	5.3	.....	.....	.....	.....
Grade *B* Fuel								
Viscosity[a]	259	247	222	220	286	277	279	282
Dilution, per cent	2.8	3.3	5.5	5.5	2.6	3.1	4.2	5.4
Grade *C* Fuel								
Viscosity[a]	261	248	231	222	278	256	273	255
Dilution, per cent	2.2	3.5	5.0	5.5	3.0	5.0	5.5	7.0
Grade *D* Fuel								
Viscosity[a]	272	265	254	215	272	255	235	213
Dilution, per cent	2.8	4.0	5.5	6.7	3.5	5.5	7.0	12.0

NEW OIL USED; VEEDOL MEDIUM

Specific Gravity	0.899
Baume, deg	25.7
Flash Point, deg. fahr	420
Fire Test, deg. fahr	480
Pour Test, deg. fahr	25
Viscosity: At 100 Deg. Fahr., Saybolt sec.	290
Viscosity: At 130 Deg. Fahr., Saybolt sec.	143
Viscosity: At 212 Deg. Fahr., Saybolt sec.	51
Boiling Point, deg. cent	305
Boiling Point, deg. fahr	581

[a] At 100 Deg. Fahr.
[e] Quart of oil added by mistake.

TABLE 12—PERCENTAGE OF CAR-MILES PER GALLON OF FUEL, REFERRED TO GRADE-*B* FUEL

Car	Carbureter Set for Grade *B* Fuel				Carbureter Set for Each Fuel			
	Fuels				Fuels			
	A	*B*	*C*	*D*	*A*	*B*	*C*	*D*
W	100	100	100	101	106	100	96	96
X	98	100	100	103	.....	.....	.....	.....
Y	96	100	104	106	103	100	102	99
Z	98	100	102	102	101	100	99	98

of the less volatile fuels. It was realized that under summer weather conditions the dilutions obtainable would be relatively small; for this reason, the tests were not made more comprehensive.

The results are summarized in Table 12, on the basis of the number of miles per gallon.

This table gives the miles per gallon of each fuel, expressed as the percentage of that obtained with the Grade-*B*, or reference, fuel. The greatest difference in miles per gallon is in the case of car *W* when the carbureter was adjusted for each fuel. In this instance the number of miles per gallon with Grade-*A* fuel was 10 per cent *greater* than with the Grade-*D* fuel. However, it will be noted that with the same adjustment for all fuels, the number of miles per gallon on Grade-*A* fuel was 1 per cent *less* than on Grade-*D* fuel. This fact emphasizes the sensitivity of the results to small changes in the carbureter adjustment and, hence, the consequent difficulty of making such adjustments. It seems likely therefore that this 10 per cent difference is an effect due to improper carbureter adjustment, rather than to an inherent difference in the fuels themselves. If, however, this was not the case and a difference of this magnitude existed, when it is considered that the relative production from a barrel of crude would be 44 per cent greater with Grade-*D* fuel than with Grade-*A* fuel, there is no question that, from the standpoint of the number of miles per barrel of crude oil, the economic advantage would lie with the Grade-*D* fuel.

An examination of the results obtained with the other cars when the carbureters were adjusted for each fuel will show that the maximum difference between the fuels is about 4 per cent. In this group a car is included that represents probably 50 per cent of the total number now in use.

It is concluded from these tests that, on the basis of the number of miles per barrel of crude oil, the advantage among the fuels tested lies with the fuel of lowest volatility when used under summer conditions. Whether the use of this fuel represents a real economic gain depends on whether its use will result in disadvantages of sufficient magnitude to offset the gain in the number of miles per gallon of crude oil.

Investigation Under Low-Temperature Conditions

After considering the results of the summer tests, the advisory committee, representing the Society of Automotive Engineers, the American Petroleum Institute and the National Automobile Chamber of Commerce, decided to continue this work under cold-weather conditions. It was the consensus of opinion of the members that if there were any marked differences between the four test-fuels in the number of miles per gallon, the ease of starting and the crankcase-oil dilution, these differences might be more evident when testing the fuels under winter conditions. In addition to obtaining purely comparative data, a broadening of the scope of the program was authorized to permit making a study of the conditions that would be of major influence on the questions under investigation; namely, economy, ease of starting, acceleration and crankcase-oil dilution. On this basis, a program of low-temperature tests has been laid-out which aims to determine, first, what conditions exert the most influence on the questions under investigation and then to obtain quantitative measurements with each fuel under the conditions thus determined. The initial stages of this investigation are being carried out in the laboratory, where easy and accurate control of conditions is possible.

In general, the laboratory investigation aims to discover the conditions under which a richer mixture is required with one fuel than with another for a given performance. When these conditions are found and the difference in the fuel-consumption is measured, the results are applicable to service conditions by determining through actual road-tests, or other means, how often these conditions occur in ordinary driving. As an example, suppose one of the fuels required a richer mixture than another only during starting cold and accelerating to normal speed. If this richer mixture were obtained through the use of the choke and the carbureter adjustment were not changed, the difference in the fuel-consumption would depend principally on the amount of cold-starting and acceleration included in the ordinary day's driving under cold-weather conditions.

A definite program for road tests under winter conditions has not been formulated as yet, because the details of this program will be influenced largely by the results obtained from the laboratory work.

THE DISCUSSION

R. E. Carlson:—The paper, as read, covers the work under summer conditions and states briefly the purpose of the work under winter conditions. This winter program will be supplemented by such road tests as are required, the details of these road tests being dependent largely on the results obtained from the laboratory work under winter conditions. Fig. 11 is a schematic diagram of the arrangement of the apparatus for the laboratory tests.

We have made a very large number of tests in the laboratory under various conditions of load and temperature. We have also made a number of acceleration tests.

The curve at the left of Fig. 12 shows the comparison of the four fuels at a jacket temperature of 85 deg. cent.

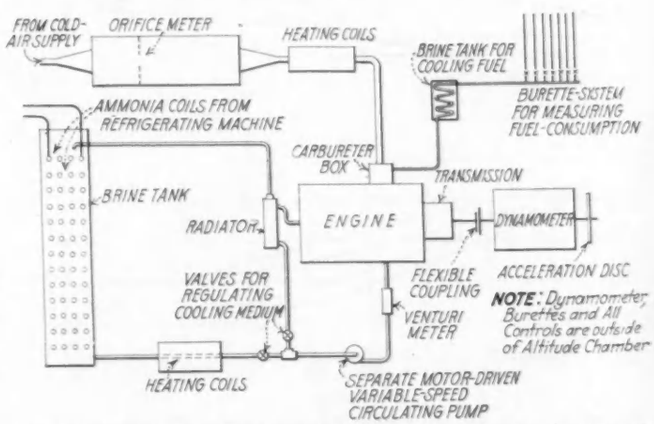
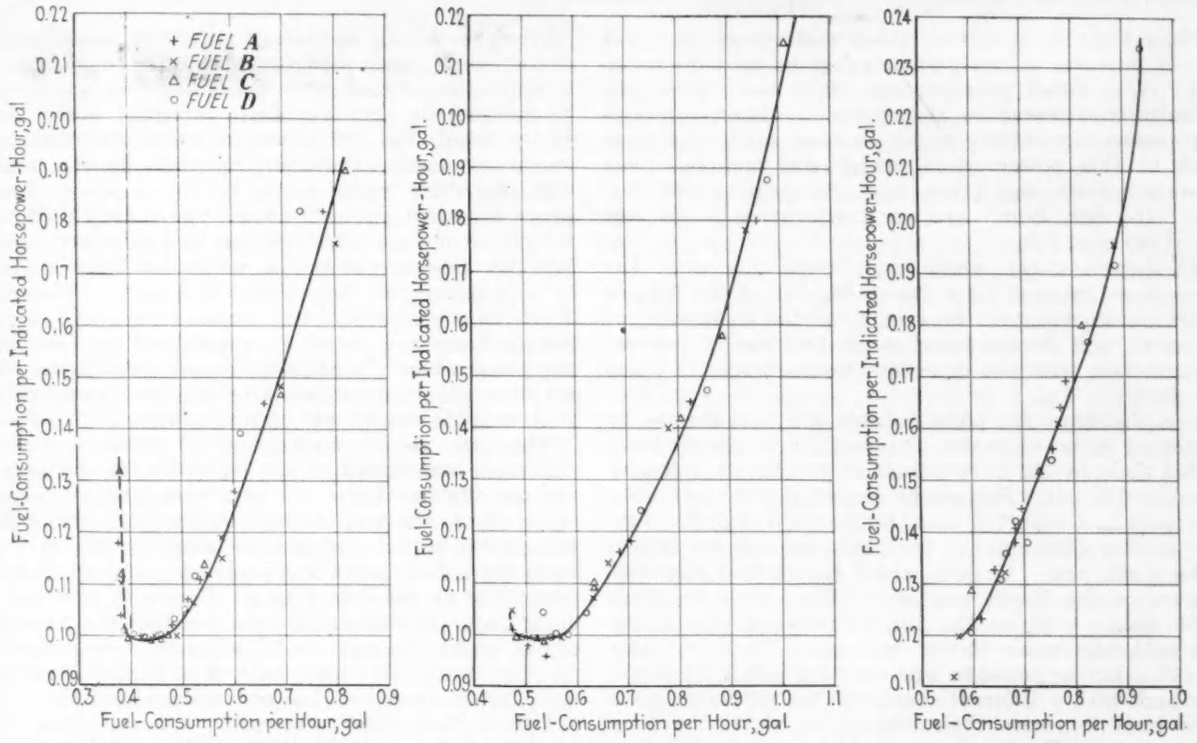


Fig. 11—Diagram Showing the Arrangement of the Apparatus Used in the Low-Temperature Laboratory Tests



Jacket Temperature — 10 Deg. Cent. (14 Deg. Fahr.) Air Temperature 65 Deg. Cent. (149 Deg. Fahr.)

Jacket Temperature 85 Deg. Cent. (185 Deg. Fahr.) Air Temperature 65 Deg. Cent (149 Deg. Fahr.)

Jacket Temperature 10 Deg. Cent. (50 Deg. Fahr.) Air Temperature — 15 Deg. Cent. (5 Deg. Fahr.)

FIG. 12—COMPARISON OF THE FUEL-CONSUMPTION OF THE FOUR FUELS UNDER DIFFERENT TEMPERATURE CONDITIONS, THE LOAD AND THE SPEED BEING CONSTANT

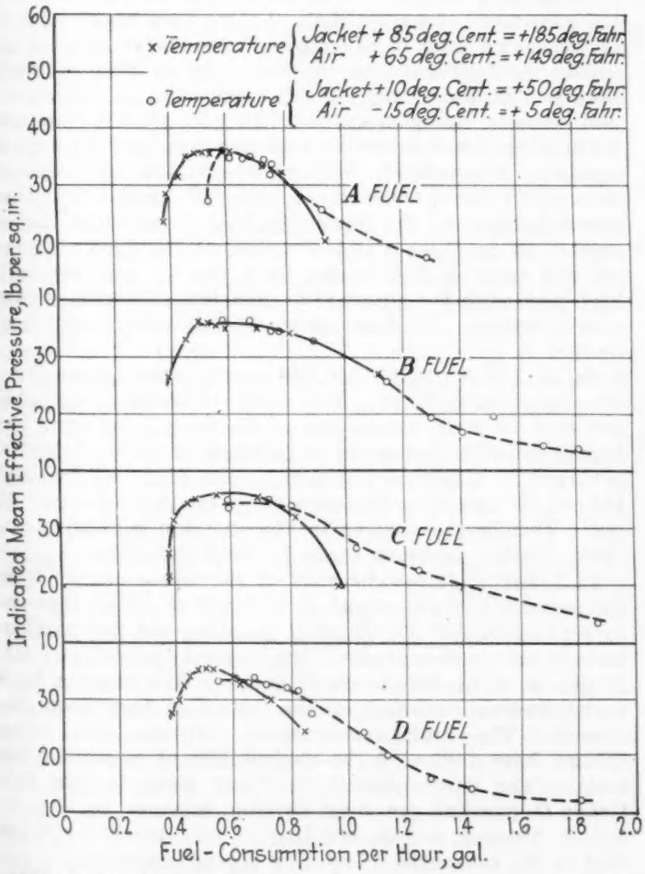

× Temperature { Jacket + 85 deg. Cent. = +185 deg. Fahr. Air +65 deg. Cent. = +149 deg. Fahr.
○ Temperature { Jacket +10 deg. Cent. = +50 deg. Fahr. Air -15 deg. Cent. = + 5 deg. Fahr.
A FUEL
B FUEL
C FUEL
D FUEL
Indicated Mean Effective Pressure, lb. per sq. in.
Fuel-Consumption per Hour, gal.

FIG. 13—COMPARISON OF THE RELATION BETWEEN FUEL-CONSUMPTION AND INDICATED MEAN EFFECTIVE PRESSURE UNDER DIFFERENT TEMPERATURE CONDITIONS

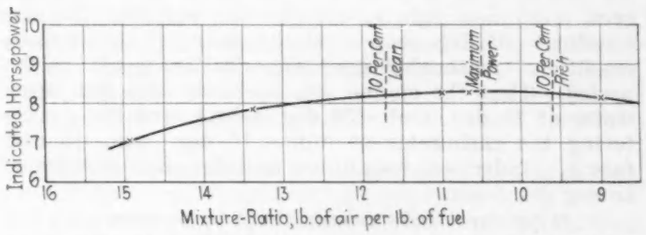


FIG. 14—CURVE SHOWING THE RELATION BETWEEN THE INDICATED HORSEPOWER AND THE MIXTURE-RATIO

(185 deg. fahr.), air temperature 65 deg. cent. (149 deg. fahr.) and load of 3 b. hp. at 600 r.p.m. It will be noted that the points for the four fuels fall closely together at the lower portion of the curve, which represents normal operation so far as fuel-consumption is concerned.

The central curve gives the same comparison with the same brake-load, but at a jacket temperature of minus 10 deg. cent. (14 deg. fahr.) and air temperature of 65 deg. cent. (149 deg. fahr.). The curve at the right gives the same information at a jacket temperature of 10 deg. cent. (50 deg. fahr.) and air temperature of minus 15 deg. cent. (5 deg. fahr.). It can be seen from these curves that there is practically no difference between the four fuels under conditions of constant load and constant speed.

Fig. 13 is interesting because it brings out the fact that it is possible to run a very much richer mixture under cold-temperature conditions. The crosses represent readings taken under normal temperature conditions, the jacket at 85 deg. cent. (185 deg. fahr.) and the air temperature at 65 deg. cent. (149 deg. fahr.). The circles represent readings taken with the jacket at 10 deg. cent. (50 deg. fahr.) and the air temperature at minus 15 deg. cent. (5 deg. fahr.).

From Fig. 14, it will be noted that the power curve is very flat over a considerable range of mixture variation. This curve perhaps will make more clear the difficulty experienced in attempting to obtain the optimum carbureter-setting under summer conditions inasmuch as this power curve, which was obtained from laboratory tests, was taken with the jacket at 85 deg. cent. (185 deg. fahr.) and air temperature at 65 deg. cent. (149 deg. fahr.).

Mr. James, under whose supervision this work has been carried on, and from the standpoint of the Bureau of Standards deserves the credit for the conception of this work, will discuss some points that are of interest in connection with the dew-point temperatures of these four fuels.

W. S. JAMES:—The point I would like to make can be illustrated by an example. Suppose the people on Mars wanted to know the temperature of the Earth, and sent a man to find out. Suppose he landed at the north pole, went back and reported that the Earth was cold. Suppose another Martian was sent out and that he landed at the south pole. He also would report that the temperature of the Earth was cold. The people on Mars might reason that, as the two extremes of the Earth were cold, the whole Earth was cold. If, later, some other Martian happened to land on the Equator, he would come back with a different story, and the people on Mars would have to revise their conclusions as to the temperature of the Earth. I am wondering whether we are not almost in the same situation, when considering the results now available from the winter work.

For instance, we tried to cover the two extremes. The engine was operated with jacket heated to 85 deg. cent. (185 deg. fahr.), and the air entering the carbureter to 65 deg. cent. (149 deg. fahr.). Under those conditions, reasonably good vaporization would be expected. Then the engine was operated with the jacket water at 10 deg. cent. (50 deg. fahr.), and the air entering the carbureter at minus 15 deg. cent. (5 deg. fahr.). Under both conditions, no differences were found among the fuels.

In going over these results there is an interpretation that may be as incorrect as that which the Martians might have made of the temperature of the Earth. Although there is as yet insufficient evidence to draw definite conclusions, *there may be a difference* between the fuels within the range indicated between the extremes mentioned.

From an examination of the dew-points, as determined by D. P. Barnard, 4th, when using Prof. R. E. Wilson's method, a 15 to 1 mixture of Grade-*D* fuel would be dry at approximately 46 deg. cent. (114.8 deg fahr.); and a similar mixture of Grade-*A* fuel would be dry at 9 deg. cent. (48.2 deg. fahr.). Therefore, if the manifold temperature is above 46 deg. cent. (114.8 deg. fahr.), there can be complete vaporization of all fuels.

It is agreed generally that the differences in economy that are likely to be obtained with several fuels are more affected by the distribution of the fuel to the cylinders than by any other factor. If the engine is operating with an intake-manifold temperature that can give complete vaporization, the manifold may be distributing mainly gas or vapor in the case of each of the four fuels; and, with manifolds as generally constructed, there is very little doubt that there would be little difference in distribution among the four fuels. On the other hand, when running at low temperatures, the intake-manifold temperature was about minus 13 deg. cent. (8.6 deg. fahr.) in the case of all four fuels. Therefore, it may be that all four fuels were practically liquid while being distributed by the manifold.

Since the differences in the amount of vapor formed respectively in the four fuels probably would be relatively small, the differences in their distribution also would be small. However, the fact that a manifold will distribute vapor alone, or liquid alone, does not prove necessarily that the same manifold will distribute a mixture of vapor and liquid as well as either one alone. Whether this is true or not, we do not know. We want to emphasize the fact that this work is incomplete. There is a possibility that, because we have gone completely from one extreme to another, we have missed the place where the difference lies. From the results we have obtained so far, I believe we cannot estimate very well the magnitude of that difference.

This may also be an explanation of the fact that no difference was found in the operation of the cars during the summer tests. In each case, and as is general in summer, the engine was warmed-up; the exhaust-manifold was hot and the air entering the carbureter from the hot-air stove was probably about 60 or 65 deg. cent. (140 or 149 deg. fahr.). The work that has been done under winter conditions confirms the results obtained under summer conditions, and it is rather hard to predict at this time what will happen during the warming-up period of fall and winter operation.

I think that these considerations do not make it impossible to draw conclusions with regard to summer operations, but they may have an important bearing on the winter work.

DR. VAN H. MANNING:—Mr. H. M. Crane has contributed very largely to this work. He has gone through the process of education that all of us have been through. It took some time to educate the automotive and the oil industries in regard to the necessity of this program that is now under way. I can recall that, in 1920, complaints were being made that the oil industry was not furnishing the automotive industry the kind of fuel it wanted. The subject came up at our Chicago meeting as a topic for discussion. I objected to the title that was submitted by the Society in that it indicated that it wanted to establish a uniform automotive fuel. My reply has been, and is today, that the oil industry will keep pace with the automotive industry. What is needed is cooperation. We have shown in this work that it can be had.

In 1911, there were 750,000 cars in use; today there are about 12,000,000. You have increased over 1250 per cent in your production while the oil industry has kept pace with you with an increase of only about 100 per cent in crude-oil production. In 1911, we had 315 bbl. of oil available for each car. In 1922, we had 47 bbl. That is the answer to the question regarding the progress that is being made by both industries.

T. J. LITLE, JR.:—The crux of the whole matter is in the summary of the report in which it is stated that the drivers preferred the Grade-*B* gasoline, did not particularly object to the Grade-*C*, but in most cases found difficulty in using the Grade-*D* fuel. I find that to be a pretty general comment on the tests that have been discussed. The high crankcase-oil dilution, and other things, have indicated the desirability of resuming the test in the winter months. If we have to use this Grade-*D* gasoline we may develop schemes to use it; but, at present, we do not like it very much. I think that is the consensus of opinion among engineers.

I think we have not been told directly by the oil industry that it cannot produce a better gasoline. Some

oil-refiners are not using the cracking method for the purpose of producing more gasoline. Some of them are using it to a limited degree. The patent situation, of course, enters into the matter. Some companies are known simply as skimming companies. I wonder if the oil companies are in the position of some manufacturers who are still using obsolete machinery. An uptodate manufacturer scraps his old machinery every few years and buys the latest and most improved type.

Will we have to use this Grade-*D* gasoline? Is that necessary to the proper operation of the industry? We do not want to use it. We wish the refiners would make a great effort to improve the quality. In the automotive industry, we have had some cases where we decreased the price and increased the production. I wonder if that is possible in the oil industry. It seems to me that is what we must know to discuss this problem intelligently.

F. A. HOWARD:—It is just a dollars-and-cents question with the oil industry what the grade of gasoline is, within the limits of supply. Aside from the patent situation, the elements of importance in cracking are the investment and the operating costs.

It should not be lost sight of that cracking is no solution of the problem we are discussing now; that is, of the relative cost and value of the Grades-*A*, *B*, *C* and *D* fuels. Cracking merely produces what might be described as a synthetic crude-oil. If everyone were cracking oil, there would still be the same production difference and the same price-differential between gasolines of Grades *A*, *B*, *C* and *D*; so, cracking is merely to be regarded by the automotive and the petroleum industries as, in effect, an increase of the supply of crude, in a limited sense.

Referring to the history of this joint industry of ours, the transportation of the American public in automotive vehicles, I divide it into three periods. The first period terminated about 1914. In this there was a constant change, or "degradation," in the quality of gasoline, corresponding with the increased demand for that product. About 1914, there came a period of organized resistance to that change. In our own territory on the Eastern seaboard, that first took form in the statutes of South Carolina, in which it was attempted to fix the specifications of motor gasoline at 92 per cent distilled off at 302 deg. fahr.; that is, an 8-per cent residue above 302 deg. fahr. The gasoline that was actually being made on the Eastern seaboard at that time ran about 25-per cent residue at 302 deg. fahr. The Grade-*B* gasoline of the tests under consideration runs perhaps 40 per cent residue at 302 deg. fahr.

This period of resistance to change in the quality continued, and was reflected by legislation, as well as by more or less unpleasant relations between the representatives of the automotive and the petroleum industries, until about 3 years ago. Then the second period began—the period of trying to substitute information for prejudice, to find the facts; the period of scientific investigation.

We have had a movement that has been almost like the swing of a pendulum. It has been increasing in speed. Our knowledge, and our efforts toward increasing our knowledge, have been increasing at a very rapid rate for the past 3 years. What I am afraid of now is another period that I think none of us would like to face. That is another period of resistance to change based, this time, on a limited amount of scientific knowledge and investigation.

It seems to me that a scientist or an engineer, in so far as he subscribes to the true doctrines of science, has two duties in the world; one is to ascertain facts and the other is to preach the scientific spirit to everyone with whom he comes into contact. That spirit can best be defined by the two words, humility and tolerance, an abiding faith in one's own fallibility and a respect for the opinions of others.

If that is a true definition of science, it seems to me that the Research Committee of the Society has, up to the present, actively entered only half of its field; and the same is true, I believe, of our petroleum research organizations. It has very actively entered, with excellent results, the field of really increasing our knowledge on the subject in hand. It has, however, taken no active part in teaching the world that everyone, including the scientists themselves, is fallible and that any man who is in good faith trying to do a good thing may be right. I am thinking of that concretely, as applied to any attempts to determine and to fix, or to impose upon others, our ideas of what is the correct quality of gasoline or of lubricating oil.

The petroleum business is a very peculiar one. We like to call ourselves manufacturers, and sometimes we like to call ourselves chemists; but that is stretching both terms pretty far. Practically, what we do is to pass along to the automotive industry something that is sifted out of a deposit that nature gave us. That is about all. We polish it up a little bit; and sometimes we wish we had not polished it that much. Fundamentally, the automotive industry is merely getting what the Lord provided in the way of natural crude-oil. Any other conception of a basic-fuel industry would be wrong. No fuel industry could exist that was based on anything that was really a manufacturing industry. I think I said once before that the purpose of fuel is to save human labor and not to represent an expenditure of human labor. Therefore, fundamentally, this petroleum business is a business merely of passing along, with as little change as possible, what comes from the ground.

Another aspect of this rather peculiar situation is that the oil industry is not built on bed-rock. Both the oil and the automotive industries are built on the shifting sand of being able to find from year to year increasing supplies of material that will come out of a hole in the ground in a liquid form so that it can be pumped to its market. No one knows what the future holds for us in that direction. It seems to me that, considering all of these angles of our joint industries (they are almost cooperative industries from a business aspect at present), we are facing a situation that demands, more than any industrial situation ever demanded in the past, the truest use of the scientific spirit that is, we must not only determine our facts, but we must preach to the legislators, to the public and to everyone else, that non-interference, a respect for the other man's opinions, is the thing by which they must guide their conduct.

C. S. KEGERREIS:—Several factors must be evaluated before the public can use heavy fuels satisfactorily. The following are some relative data on oil dilution when using kerosene. The oil was measured when poured into the crankcase and again on removal. In all cases the specific gravity was noted. The oil was composed of 50 per cent Mobil B and 50 per cent Mobil A. The engine was operated under different loads, up to 50 per cent load, for approximately 15 hr., during which period the mixture-ratio was changed from lean to rich so that poor operation resulted at either extreme. The result on kerosene, which is heavier than the Grade-*D* fuel,

shows about 0.7-per cent dilution per hr. based on the specific gravity.

As yet, we do not know the critical limit for dilution; that is, the point where a marked detrimental effect on the engine can be noticed. We often hear gossip about burned-out bearings caused by oil dilution; however, actual evidence on these cases is lacking. To establish this critical point definitely, more research must be conducted along this line before the public can use a heavy fuel.

The public must use the heavy fuels soon, and hence the automotive industry must develop carburetion systems that will prepare the fuels satisfactorily for efficient combustion. If the petroleum and the automotive industries are really to cooperate and supply us with a fuel with which good performance can be obtained, I think this must come gradually over a period of perhaps 4 or 5 years. By improving the cars and decreasing the volatility of the fuels, the public will get the same satisfaction out of the Grade-*D* fuel as we are now obtaining from such a fuel as the Grade-*B* type. The useful life of a car is about 5 years. The cars now built, and those to be built during the next few years, will not be too troublesome in starting or in acceleration and general performance.

I. K. GILES:—The entire problem is an economic one, not only from the point of view of the oil refiner, but from those of the car builder and the consuming public. The average refiner is desirous of producing a satisfactory fuel. He fully intends to do so, but he has to have the evidence to show what a satisfactory fuel is. Fortunately, the various people interested are now working in harmony and gathering data on what they can find out about satisfactory fuels. As the work goes on, there will be certain contradictory results. Progress cannot be delayed by taking an indefinite amount of time to try to explain these contradictory results as they occur; therefore, the final result will have to be a general compromise. After the work is "completed" and the various interested parties have had a chance to go over it, the final task will be the proper interpretation by competent people of the results obtained. Then specifications should be drawn up that will yield the greatest possible satisfaction to the oil producer, the refiner and the consuming public.

O. C. ROHDE:—My first question is in regard to the effect of distribution through the different cylinders, as it relates to this problem. We know that if we take a fuel of low volatility and have an engine that gives poor distribution, our difficulty will be emphasized; conversely, if we have a fuel of high volatility, it will be minimized. In the more exact investigations, has this question been given consideration, and how has it been approached?

My second question has to do particularly with the winter work, where the element of starting becomes a factor. How much attention was paid to the gap-setting of the spark-plugs used in these tests, so that it would be uniform and give uniform starting conditions?

H. E. PENGILLY:—I think that the results of this test, when averaged as a whole, taking into consideration all the variables, have shown the best economy of the Grade-*B* gasoline, which is approximately the gasoline we are getting at present. That is a point in carbureter setting. In other words, those conducting the tests were familiar with the gasoline and probably set the carbureters to get the best results out of it. The design of engines has been based on gasoline of about that character for at least 2 or 3 years. In other words, the builders of the cars, knowing what fuel they had to use, have attempted to get the best results possible from it. Some car-makers have gone too far in manifold design in an attempt to handle heavy gasoline. They would like a little heavier gasoline to show the best fuel-economy; whereas, others who have lagged behind in this respect are not satisfied with the gasoline that they are getting today.

MR. CARLSON:—With reference to the question concerning distribution, the primary object of this investigation was to obtain a comparison of the four test-fuels when used in average cars. For this reason, throughout the tests, we have used the cars selected without changing their original equipment. We have made no attempt to study the effect of the four fuels on distribution when different manifolds are used.

As to spark-gap setting for starting under winter conditions, we have not carried on starting tests to date. Our work has embraced runs under various load and temperature conditions, as well as acceleration runs. We are running crankcase-oil dilution tests. We expect to run tests to determine whether there is any difference in the four fuels with regard to ease of starting.

PRESIDENT B. B. BACHMAN:—What we are really after is to find out what effect a change in volatility would have on the gasoline consumption of the cars that are in use. We can expand the research program to cover a great many interesting things, but that is the fundamental question we have been trying to answer. We have some 12,000,000 cars in operation.

HERBERT CHASE:—It might be worth while to give, in connection with the table of results, a record of some of the characteristics of the engines that were tested. If it is not permissible to give the names of the builders, it might at least be possible to say what kinds of manifold were employed, especially as to their "size" and the method of heating, and to give some other particulars about the engines used in these cars that will enable one to conclude what factors influenced the results obtained.

PRESIDENT BACHMAN:—My impression is that there were some restrictions with regard to the information that we could supply.

DR. H. C. DICKINSON:—In that connection, those tests were run by 10 of the companies. Nine of them turned in their results pretty promptly, one company reported recently. The work was done as has been outlined; it was laid-out by the Research Department and the plans were followed pretty generally as they were laid out. After the work was completed we had a conference with representatives of each one of the companies involved. Two or three of the companies, for reasons they thought were good and we had to accept, wished to have no results published that would make it possible to identify the different makes of car. The main reason was that, while they were willing that any engineer should have the results, they were not willing to throw them open for use by the advertising departments of either their own or other companies, a reason that, perhaps, is sound.

With reference to winter tests, the program as laid-out for the summer tests will probably be carried out in duplicate in February, 1923, with slight modifications. Most of the companies that ran the summer tests have already signified their willingness to repeat the operation during the coldest part of the year, and we expect that this work will be begun as soon as we can prevail upon some of our petroleum friends to supply the necessary fuels. There seems to be some little difficulty about getting promptly a supply of the fuels we want for the purpose.

The Motor Truck and Our Railroads

By Elisha Lee[1]

Annual Dinner Address

I WELCOME very sincerely the invitation that gave me the opportunity of being here tonight. Naturally, for personal reasons, the honor that it carries is keenly appreciated. Beyond that, I find a deep source of satisfaction and assurance in the thought that you have asked a railroad man to address you during the course of your Society's annual meeting, and, I believe, as the only speaker outside the ranks of your own profession. May I express the hope that this will serve to symbolize the idea that the railroad and the motor vehicle are not rivals seeking to crowd each other out of the field of patronage, but are agencies capable of developing side by side and of finding their own broadest field in joining resources for the perfecting and rounding-out of the public service of transportation.

At the outset I wish to express my most sincere and profound admiration for the magnificent achievements of the American motor industry. The story of those achievements, practically all wrought in the short space of 20 years, and a large proportion of them in less than 10, constitutes a record for the marvelously swift creation of new wealth, capital and work, and for the elevation of the living standards and ambitions of many millions of people, which I believe cannot be paralleled in history.

In making that statement, I do not sacrifice any of the pride I have always felt in my own calling, and in the railroads as the great arteries of the Nation's life. But I am obliged to realize that within two decades the American automotive industry has risen from practically nothing until today, with all its operating vehicles, its manufacturing plants, its selling establishments, its fuel, storage, service and repair-stations, it represents, according to the estimates of your organizations, a substantially greater investment of capital than do the railroads and employs more hands, in these respects outstripping the growth of the railroads over nine decades.

Those are facts to which none of us should shut our eyes, least of all railroad managers. They are also facts from which we should be very careful to avoid drawing dangerously wrong conclusions. One of these conclusions, which from its novelty and spectacular appeal commends itself only too easily to many people, is that motor vehicles and concrete highways are destined to erase the railroads from the map. The truth, I believe, is that they are destined to add very greatly to the utility and efficiency of the railroads by rounding-out and completing the rail service, and relieving the railroads of certain forms of service that are burdensome and costly when performed over fixed tracks and with the necessarily heavy equipment of the steam lines, but can be made attractively profitable to the loose-footed, free-moving motor car. This is the aspect of the matter toward which, in my opinion, both the motor industry and the railroads, in their own true interests and in the interest of transportation progress, should endeavor to guide public thought and discussion.

Experience shows that radically new ways of doing things tend to create new fields of their own rather than encroach greatly upon what is older. For instance, we still write letters and use the mails in spite of the telegraph and telephone; we doubtless write far more letters than we would need to write had electrical communication not been invented to add enormously to the general volume of business activity. We still write with pens and pencils in spite of typewriters. We still write in longhand notwithstanding the seemingly great advantages of shorthand. We use pens dipped in ink in spite of fountain pens.

The telephone has not wiped out the telegraph, as many people thought it would. The telephone's chief development and utility have been in fields the telegraph could never have touched. And the telegraph, on the other hand, retains unchallengeable superiority over the telephone for many very important purposes, and seems likely to do so indefinitely.

Wireless telegraphy has made its own place in a very important field of utility and service where the wire systems could never have functioned; but in the fields where the wire telegraph was commercially established, the wireless has never made measurable headway. The radio telephone seems to be following a similar course with respect to the switchboard systems of telephony.

To take a different illustration, there are many more horses in the United States at the present time, the census tells us, than in 1900, when, as you may recall, prophets were busy proving how horses could soon be dispensed with as a result of "horseless carriages."

Many other similar examples might be given. They all seem to demonstrate one general truth, which is that the human race, in its march of progress, constantly accumulates new resources and facilities; adopts the new readily and swiftly, but rarely discards, and then only very slowly.

Motor Vehicles and the Railroads Not Competitors

So I think it is likely to be with the motor vehicle and the railroad. The part of the motor vehicle, in rendering transportation for hire, is not to do what the railroad is already fitted and equipped to do with full success and satisfaction; it is to do what the railroad is not able to do at all, or else does only with difficulty and imperfect success.

Events to the present time certainly bear out that view. There are now, it is stated, nearly 12,000,000 motor vehicles in the United States, all busily engaged in producing transportation in enormous volume. Yet since 1900, when the motor industry may be regarded as having its rise, the freight traffic on our railroads, measured in tons and passengers carried one mile, nearly tripled. In the last three years, the demands for transportation made upon our railroads have exceeded those of any previous era, and it is common knowledge that the question how to increase the carrying capacity of the railroads is the Nation's most pressing economic problem at the present time.

We thus have what superficially seems to be an anomaly in the rise of an immense new transportation agency simultaneously with unprecedented demands upon the services of the older agency. The explanation, of course,

[1]Vice-President, Pennsylvania Railroad Co., Philadelphia.

is the very obvious fact that the vast bulk of the transportation rendered by motor vehicles is in entirely new fields. It constitutes additions to, rather than substitutions for, that previously rendered by the railroads. For that reason, when the new business booms developed, the railroads felt the pressure almost as though commercial motor-transport did not exist. Indeed, the vast impetus to motor-car building in the last few years was one of the most notable causes of the increased demand upon the railroads for service. So we have another interesting situation in the fact that the expansion of a new agency of transportation has actually added greatly to the demands upon the old.

In discussing the relationship of motor transport to the railroads, we necessarily have in mind the possibilities for the further development of motor vehicles in the field of transportation for hire. I of course share the realization of railroad officers, generally, that this activity, although already of important scope, is still in a state of comparative infancy and is entering upon what should be a period of lusty and vigorous growth. Nevertheless I have indicated the opinion that the resulting problems, as relating to the railroads, will not, except in secondary degree, be those of competition, but chiefly those of coordination.

For holding those views, I have a very simple reason. Such profits as the railroads are able to make at all come practically altogether from the mass transportation of freight and passengers over at least considerable distances; in other words, from what we may term the "wholesale" departments of transportation. This is just the form of service in which experience shows that trucks cannot consistently earn real profits. On the other hand, those forms in which trucks can and do make money are almost invariably the strictly "retail" forms, in the rendering of which railroad operation practically always involves losses, and sometimes very heavy ones. It is very important to note in this connection that the demands of modern large-scale industry for a constantly increasing volume of mass transportation are irresistibly compelling the railroads to adapt their motive power, cars, structures, terminals and operating methods more and more to the "wholesale" forms of service and, inevitably, less and less to the "retail" forms. That supplies the keynote for any sound consideration of the economic coordination of rail and motor transport.

The question of competition in reality seems seriously important from only one point of view, and that is the enlisting of the assistance of the leaders in the automotive industry in discouraging futile attempts at losing forms of competition. Such experiments are harmful in two ways. They reduce railroad earnings while they last, and waste and dissipate the energies of truck operators that might be utilized in productive channels. I am satisfied that the railroads and their patrons urgently need the cooperative services of both motor trucks and motor passenger-lines, and can, therefore, ill afford to see these forms of enterprise go to waste in fruitless and needless efforts at competition with transportation agencies that are already functioning successfully. I will endeavor to lay before you some of the specific ways in which it seems to me promising opportunities lie for bringing about a coordination of motor and rail services, with resulting advantages to both, as well as to the using public. Please consider my views broadly, as being personal conclusions and not as necessarily representing formally adopted policies of the railroad system with which I am associated or of the railroads in general.

Presumably, we all agree that, as a fundamental to any constructive approach, there must be open-mindedness on both sides. Automotive interests must cease to defend or encourage cut-throat sporadic forms of competition, while the railroads must be ready to relinquish to the motor trucks and passenger buses those forms of service in which the latter can clearly demonstrate superiority. There are truck dealers who will sell almost anyone a truck on installments, to operate almost anywhere, regardless of whether the venture is sound or not. Such a policy, which it is certainly within the power of the manufacturing interests to curb or correct, is neither more nor less short-sighted than that of the unprogressive railroad-official who blindly refuses to surrender a dollar of gross revenue, regardless of net results, on the principle that a railroad can never afford to give up anything or recede from any field.

Opportunity for Coordination

It seems to me that one of the most important opportunities for useful and successful coordination of motor and rail facilities may be expected to lie in organizing smooth-working freight pick-up delivery motor-services in the larger cities, for the less-than-carload traffic, to be operated in connection with inter-city hauls by rail. Such an arrangement would extend the scope of rail transportation by making it a really complete service from the premises of the shipper to the premises of the consignee. It would allot to each transportation agency employed the portion of the service that it is pre-eminently fitted to perform; to the truck the terminal work, and to the railroad the line-haul. This subject is of vital importance to the railroads, their patrons and the builders of motor vehicles, alike. If such a service could be worked out for the larger centers of the Country generally, it would constitute one of the most momentous advances ever made in the handling of railroad traffic, and create an economically sound market for the product of the motor-truck makers.

In approaching this question it may be noted that the tendency usually is to dwell largely upon the possibilities of reducing the cost of distribution, through the establishment of such a system of store-door collection and delivery, in the sense of making possible a structure of through-rates that would be lower than the combination of the existing rail-rates and the present costs of collection and delivery at each end. It may be doubted whether that is really the best "selling-point" upon which the automotive interests can focus attention, or whether it is actually capable of immediate realization. It must be remembered that to inaugurate a service such as we are talking about, it will be necessary to enlist the aid of considerable new capital. A service of the character contemplated would certainly be a vast improvement over the haphazard facilities for collection and delivery now usually at the disposal of shippers and consignees who do not have their own trucks. It would constitute a notable addition to the present service and should be worth a fair and reasonable price. It is difficult to see upon what other basis the needed capital can be attracted.

In convenience and speed such a service would lie midway between the present ordinary freight and the express. It would be substantially a semi-express service, affording complete through transportation, rendered by a combination of motor truck and freight train instead of by a combination of truck and passenger train. The aggregate charges would of necessity have to be adjusted in proper recognition of the character of the service, always bearing in mind that new capital must be attracted if trucks are to be purchased and operated.

There would be many economies outside of the rates themselves. Among them may be enumerated the greater dependability of service, the reduction of losses in transit; lower insurance-rates; greater ease in making shipping arrangements and paying bills; and a reduction in the time goods are on the way, which would amount to a saving of interest on idle capital. The shortening of the time in transit would also permit the carrying-on of business with smaller stocks, thus in another way reducing capital charges.

In other directions such a system of collection and delivery would effect many savings which, although difficult to measure exactly, would be nevertheless real. Among them may be mentioned the more efficient use of the public thoroughfares, lessening the losses and delays now incident to the street congestion and crowding that are so marked under the present totally unorganized trucking methods in general use.

The question arises whether a terminal trucking system of the kind under discussion should be operated by the railroad companies or by independent enterprises working in cooperation with them. This matter would require careful study to be answered decisively, but in the light of present knowledge there appear to be at least two important considerations favoring independent operation. One is that the railroad business is already so vastly complicated that it is very debatable whether it is desirable to add another department, requiring expert knowledge, to the functions and duties of management. The other is that, if identified with the railroads in ownership, the trucking operations would be more likely to be subjected to hampering and restrictive regulation than if independent.

Should there be a single trucking agency in each city, or several more or less competitive? The former seems to be the general rule in England, where, by the way, the collection and delivery system appears to have been working-out very successfully. For us I am not certain that the single or unified agency scheme is the best. Without committing myself definitely, I may say that there seem to be at least some good arguments for preserving a degree of competition and also for maintaining the identity, all the way through, of the services of the separate railroad lines. That identity would be largely lost if every shipper and consignee, in a given city, transacted all transportation business through the same local collection and delivery agency. On the other hand, if there were separate agencies, cooperating with each separate line of railroad, the identity and individuality of the various rail lines, and of their services, would be preserved.

I presume that many of you are aware that this system of store-door collection and delivery of less-than-carload freight, as part of a through inter-city service, has already been introduced in this Country. While still functioning only in a limited way, it may fairly be regarded as past the purely experimental stage. Certainly it merits careful study and consideration by the directing minds in the automotive industry. It hardly need be added that the adaptability of freight containers to the handling of less-than-carload freight on combined motor and rail hauls, should receive further thorough consideration, in connection with this general subject, from the viewpoints of both truck and railroad operation.

Highway-Building Policy

Outside the large cities, much interest in the coordination of rail and motor facilities centers upon the possibilities of extending the use of motor trucks as lateral feeders to the railroads, thus placing the farm products of vast and fertile, but sparsely settled, territories into better communication with the railroad lines. We may as well face the fact that any very early realization of such hopes, upon any considerable scale, will necessitate a change in the policies now chiefly dictating the building of our hard-surfaced highways. There seems to be a positive mania today for building long-distance automobile and motor-truck roads, whereas the more urgent need is probably for shorter-distance lateral highways, bringing the more remote villages and countryside into better communication with the larger towns and railroad centers. But just now no one seems to be much interested in a road project unless it is advertised to run from ocean to ocean or Lakes to Gulf, or to create some other new and striking long red line on the touring maps. That appeals to the imagination, but it is very doubtful whether it constitutes, in the majority of cases, the best expenditure of the taxpayers' money. This same policy also has an important bearing upon the possibilities of extending motor-bus service for passengers into the territories not already served by railroads or by interurban electric lines. Our new highways, inviting motor travel, are not being built in those directions for the most part. Instead, thousands of miles of concrete and other expensive roadways have been built, and are under construction, paralleling the lines of the trunk-line railroads. These highways are the great routes of the longer distance motor buses. Their coming does not assist in giving transportation service to people who previously had none. To make matters worse, in many cases, especially in the Central West, the rail lines had already been paralleled, years ago, by interurban trolley-lines, so that the advent of the concrete road and its bus lines often simply provides a third agency of transportation where one would suffice. Thus, with a serious shortage of transportation for the Country as a whole, we are confronted with a remarkable excess of facilities in certain instances.

A very striking case that came to my notice because it developed in Pennsylvania Railroad territory involves a town of about 40,000 inhabitants, located 31 miles from a Middle Western city of some 400,000 people. The populations of and the comparatively long distance between the points make it evident that the volume of traffic could not be extremely heavy. Yet investigation shows that, analyzing the service in one direction only, there are 86 regularly scheduled movements of passenger vehicles daily, including steam trains on two railroads, cars and trains on the electric lines and a number of bus lines of the public highway. I suppose that none of the services is making, or possibly can make, money under such conditions. The railroads, if they consulted their own interests only, would abandon their passenger trains at once between those points. Please observe, in connection with this illustration, that multiplication of facilities has given to those two comparatively small inland centers a greater frequency of passenger service than is afforded between New York City and Philadelphia, where the world's densest passenger traffic, over any considerable distance, is handled. Also observe that the building of the costly highway, which added the buses to the previously existing electric and steam lines, did not extend transportation service of any kind into any new territory.

One of the important effects of building highly improved roads directly paralleling the main lines of the railroad has been to reduce the travel on local accommodation trains, operating over these lines, to the point

where they show very serious losses. Yet a sufficient number of people continue using these trains to make it evident that their complete abandonment would often be a genuine hardship. We have many cases of this kind on the Pennsylvania Railroad System, especially in the Central West where, as I have stated, mile after mile of concrete and stone roads is being built parallel to rail lines already paralleled by trolleys, while the lateral roads into the farming regions and more distant villages remain almost impassable in winter. Such a highway-improvement policy is a very serious matter to the railroads and their patrons, and seems well worthy of the most careful attention of and consideration by this Society.

Motor Rail-Cars

Before coming here tonight I was requested to discuss the adaptability of motor-driven rail-cars to passenger service on existing branch railroad lines of light traffic. My reply must be that the real answer to this question lies in the hands of the automotive engineers themselves. The railroad with which I am associated is carefully studying every new design brought out, as are many of the other roads. But thus far the type has not been produced that we can regard as fully and satisfactorily solving the problem. However, we are proceeding to give a practical try-out to a number of cars of the most promising type yet produced, and other lines are following a similar course.

I can give briefly the specifications of what the successful gasoline rail-car must, from the railroad manager's viewpoint, be and do to meet with reasonable completeness the needs of light branch-line traffic. It must be capable of carrying from 70 to 80 or more passengers, with suitable baggage, mail and express space. It must be capable of a sustained speed on a level track or ordinary grades of at least 40 m.p.h. It must be reversible and capable of operation from either end. It is needless for me to say that the problem resolves itself largely into the designing of an engine of sufficient power, probably at least 100 hp., with the necessary mechanical and electrical equipment that will allow control from either end and movement in either direction. That problem is in the hands of your profession. I have no doubt that it will be solved.

Limits of Motor-Vehicle Service

There is just one more subject upon which I would like to touch, and that is the limits of distance within which the motor truck, instead of acting jointly with the railroad, may be regarded as fitted to take-over merchandise freight service in its entirety. In my opinion, all freight service within city and highly developed suburban areas should be performed entirely by truck, except those special cases involving single pieces of such great weight as to necessitate the use of railroad equipment and roadbed. Otherwise, the railroads ought to be relieved altogether of intra-city business, so that their tracks within the municipal areas may be reserved entirely for the purposes for which they were constructed, namely, the rendering of the strictly terminal service required in connection with the line-hauls.

Outside of the strictly cosmopolitan districts, the question of determining the economic limits of truck operation resolves itself into one of determining the point at which the cheaper costs of truck service within terminal zones begin to be overcome by the greater efficiency of the line-haul by the railroad. The distance would naturally differ for every center. It may sometime have to be designated more or less arbitrarily, for every cosmopolitan district, by regulative authority. Possibly a fair average distance might be 25 miles around every large city. Within a circle of some such radius most of the less-than-carload work can be done more efficiently if performed entirely by trucks. Outside of it, the greater efficiency will be obtained by the use of trucks for collection or delivery and the railroad for the intermediate line-haul.

In this connection, as throwing some light upon the results of comparatively long-distance motor freight-service, when attempted on a considerable scale, it may be of interest to you to know that out of 100 to 120 trucks now running between New York City and Philadelphia, only one line has been in business more than 2 years. The road distance is about 95 miles. Trucking began 5 or 6 years ago, during the war-time congestion of the railroads, and was for a time sustained by the abnormal conditions then existing. The fact that only one of the earlier lines has survived to the present time certainly seems to cast serious doubt upon the financial soundness of large trucking ventures over distances of such length, even when favored by excellent road conditions and great density of traffic. In fact, so far as we have been able to ascertain, the only reason trucking continues on the present scale between these two cities is that losses of capital are constantly being made up by people who apparently are unfamiliar with what is entailed.

If we come to the designation of what shall be the trucking zones in and about municipal areas, by regulation, as is certainly not impossible, there is a closely related provision that should on no account be neglected. Whenever a certain zone is declared to be truck territory for less-than-carload freight, the railroads should be permitted to abandon their form of service within it entirely. Otherwise, the trucks will be in a position to take the cream of the traffic, the higher classifications of freight moving during favorable weather, and leave the railroads, which cannot legally refuse service, the skimmed milk, that is, the lower classifications and all the work in the winter storms. Such an arrangement is neither just nor conducive to good and dependable service.

Similarly, with passenger traffic, where there is not enough to support both rail and bus lines, does it not seem proper to determine which form of service shall be continued within specified zones and which shall withdraw? When the people permit the building of hard-surface roads directly paralleling the established rail-lines, and then permit and encourage the operation on these highways of bus lines, paying nothing for their roadway, and to such an extent that the revenues of accommodation passenger-trains do not cover half the cost of operation, should the people of those communities insist upon the continued running of the trains? Does it not seem fair to call upon them to decide which form of service they desire, and to abandon the other, especially when the railroads are being subjected to constantly increased taxation to help build such highways? That is a situation which many railroads are facing in different parts of the Country. It will invariably have the result of bringing about a movement for a general reduction in passenger accommodation-train service.

In discussing the motor truck, I have referred only to the less-than-carload freight service. My views upon trucking freight that is moving in carload volumes are

(*Concluded on p.* 180)

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The Design of Commercial Airplanes

By E. P. Warner[1] Annual Meeting Paper

THE author discusses commercial-airplane design in general terms, considering the subject under the main divisions of economy, safety, speed and comfort. Under economy, mention is made of possible reductions of first cost by designing for long life and reliability, the effect of the former on the depreciation allowance being obviously advantageous. Airplane size is debated also, the trend of progress being seemingly toward the giant airplane.

Safety is stated to be dependent upon reliability, structural strength, stability, control, fire prevention and reduction of risk of injury to passengers in the event of a crash. Minimizing the results of a crash is considered suggestively.

Speed is governed almost solely by the ratio of wing loading to power loading; hence, speed will always be kept as low as possible without loss of business to competing transportation enterprises. Among desirable measures to secure comfort, adequate ventilation and the elimination of noise are included.

IT has been a common error, in discussing those technical factors that enter into the design of the flying equipment for an air line, to neglect the specific conditions under which the equipment is to be used and to speak of commercial design as though it were a thing set apart from ordinary aeronautical engineering practice and as though, furthermore, it could be treated as a unit by standardized rules. Dogmatism is always dangerous, and never more so than here, where the whole sum of the world's experience, to say nothing of that of any individual, would be insufficient to justify the laying down of iron-clad specifications for successful design, even if all of the lessons of experience pointed in the same direction. As a matter of fact they do not, and it is hardly possible to generalize on the merits and demerits of specific details of practice. At best, we can only set forth certain principles bearing on what a commercial airplane should be able to accomplish, and say that under some particular conditions the compromise best satisfying those principles has been attained in some particular manner. The word compromise is used advisedly, for nowhere is it more true than in connection with the design of aircraft for commercial purposes that some highly desirable qualities find themselves placed in direct contradiction with others, and that hardly any gain can be attained without some sacrifice.

Obviously, the first step in deciding on the general characteristics of an ideal commercial aircraft is to decide on the qualities of performance which the finished product should show. Obviously also, the first of those qualities is economy. Air lines may operate under very grave handicaps of some sorts, but it is certain that they will not continue indefinitely to operate at a financial loss, and it is therefore a prime essential that the equipment used should be such that the costs of operation will be restricted to a figure making it possible to compete on reasonably equal terms with existing forms of transport. The only exception to the necessity for economy arises in the case where a government subsidy of great liberality exists, a subsidy that amounts to a government offer to pay all the bills and make the operating company independent of the traffic. Since it is neither desirable nor possible that such a condition should ever exist in the United States, it can be wholly disregarded in considering design for operations in this Country.

Second of the requirements, and indeed subordinate to no other in importance, for it is vital, is safety. It is futile to blink at the fact that the major source of difficulty in securing increased patronage for air-transportation facilities today is the danger that the lay imagination magnifies far beyond the reality. The elimination of the gap between the real and supposed risks of air travel is a problem in public education and in the dissemination of accurate information, but the reduction of the real hazard is a responsibility definitely to be shared by the designer of the airplane and by those charged with its operation.

Third we may list speed, in which air transport, like most other modern means of transport, finds its principal justification. Were there no reason to desire speed, the transcontinental railroads would never have been laid down, and goods and passengers would still be traveling in sailing ships around Cape Horn. Were there no reason to desire speed, British officials with business in Mesopotamia would still be making the journey from Cairo to Bagdad by caravan instead of traveling by air in fewer days than the old method would have required weeks. Air transport is at present, and is likely to remain, considerably more costly than surface transport, and it can only justify its existence by demonstrating a clear saving of time for a journey. The greater the difference of cost is, the greater the economy of time must be.

The fourth and last of these fundamentals is comfort. It may perhaps be said to be less important than the others, but that is very doubtful, for it is certain that only under the press of the most urgent necessity will passengers continue to travel in an unpleasant and fatiguing manner. The whole development of modern civilization has been in the direction of increasing comfort and convenience, and of converting the articles of luxury of yesterday into the accepted necessities of today. Study of commercial aircraft of the past and present suggests that some designers have started with the idea that the passenger requires nothing except to be placed on board of a projectile and shot through space with a maximum of velocity. The cases in which the desire for speed absolutely overweighs all other considerations will, however, be found few and far between.

The relative importance of these four qualities, or rather, to be more exact, the quantitative measures which can be considered as representing satisfactory attainment in respect to the various qualities, of course differs with the type of service. This is particularly true of speed, as we can never consider that permanently satisfactory conditions have been reached in respect to economy, comfort or safety, particularly the last two. There is, however, a particular speed which is best suited for each particular service. Obviously, to take a concrete example, high speed would be much more necessary on the route from New York City to San Francisco, where it is necessary to compete with a highly developed express-train service running 24 hr. each day, than between New Or-

[1] M.S.A.E.—Associate professor of aeronautical engineering, Massachusetts Institute of Technology, Cambridge, Mass.

leans and Vera Cruz, or any other pair of points similarly served only by ships or by relatively slow overland transportation by a circuitous route. It is, of course, fundamental that economy and speed are in direct opposition, and the natural desire of those operating aircraft will therefore be to use the lowest speed that suffices to attract traffic. Only by competition among air lines themselves will speeds be forced up to levels materially above those now prevailing. At present, it seems impracticable to realize a commercial speed of more than 85 m.p.h. on lines running without subsidy, as the costs of operation at higher velocities than that become prohibitive.

Economy

To obtain economy means to reduce the sum set aside for the repayment of the first cost, as well as to reduce the costs of operation. The group of items relating to first cost, including depreciation and interest on the capital tied up in equipment, can be cut down by designing for long life and for reliability of service. The effect of long life on the depreciation allowance is obvious, and reliability enters in because airplanes and powerplants designed for a maximum of reliability can be kept continuously in service without laying up for overhauling and repairs, and the amount of capital tied up in reserve machines can thus be materially reduced. The differences in this respect among the companies now operating are really amazing, the percentage of reserve airplanes ranging from less than 100 to over 300. Since the average price of a commercial airplane is from $2,000 to $4,000 per passenger carried, it is manifestly undesirable to keep three-quarters of these costly machines idle in the hangars.

The first possibility that comes to mind in connection with design for durability is the increased use of metal construction. While there is no question that this is the best direction to pursue under some conditions, notably in the tropics, it is not at all certain that the life of an airplane for service in temperate climates is increased by the use of metal, while the cost in small lots indubitably goes up. In fact, a study of the records of operation suggests that the promotion of durability in airplanes is almost entirely a matter of a reduction of the crash hazard. The only part of the machine forming an exception to this rule is the fabric, which must of course be replaced occasionally, particularly if the airplane is kept out in the open. The cost of maintenance depends more on the general form of the airplane than on the materials employed, although some materials, particularly the metallic ones, offer an advantage in being less subject to distortion and warping than others, and therefore require less frequent realignment. For use in temperate climates at present, considerations of economy on the whole favor the use of a fuselage either of welded steel-tubing or of plywood, and a wing of wooden construction with plywood or fabric covering. On grounds of economy of maintenance, wholly apart from the running costs, the internally braced cantilever-wing offers a distinct advantage over any externally braced form.

Durability in engines is of course outside of the province of the airplane designer, except insofar as he is responsible for the choice of the powerplant. The recent extraordinary developments in increasing the effective life of airplane engines have indicated the possibility of largely reducing the economic importance of the item of depreciation.

Concerning economy of actual running expenses in the air, it is possible to be much more definite. Fuel cost is obviously reduced by the use of a minimum amount of horsepower per passenger. This is attained only at the cost of sacrifice of maximum speed and, as has already been pointed out, the extent to which speed can safely be sacrificed will be a function of the nature of the route. It cannot be too strongly emphasized, however, that for a given speed there is a wide range of choice in respect to the general arrangement of the design to be employed, and the common belief that certain types of airplane possess a tremendous inherent choice over others in respect to weight-lifting capacity is certainly erroneous. It happens that the first machines which were exhibited in this Country with any idea of commercial use were cantilever monoplanes and there has grown up, largely as a result of that priority of demonstration, a wide-spread feeling that the cantilever monoplane possesses distinct advantages over all other types for commercial purposes. As a matter of fact, a comparison of the results obtained with the machines operating on the various air-lines of the world shows very little difference between the cantilever monoplanes and the externally braced biplanes, and both of those types are in extended and successful use in Europe. As a rule, the thick-wing cantilever-type has a slight advantage in economy of operation at moderate speeds, while machines with externally braced wings give the better results when the operating speed is twice the minimum or more, because of the higher efficiency of thin airfoils at low angles of attack. In general, it can be said that an airplane having a maximum speed of 100 m.p.h. can carry 18 lb. per hp. and 9 lb. per sq. ft., giving it a landing speed of approximately 50 m.p.h. and a rate of climb high enough for safety in flying over reasonably smooth country. If 40 per cent of the total weight goes into useful load, the pay load, making an allowance for fuel for a 4-hr. flight and for the weight of one member of the crew for every 300 hp., should be roughly 4.5 lb. per hp.; this makes it possible to carry one passenger for every 40 hp. This is approximately equal to the best economy record that has been shown on any of the European commercial airplanes. The monoplanes have a distinct advantage over other types in respect to vision, but the discussion of that point can be postponed for treatment in connection with other matters bearing on comfort and convenience.

Airplane Size

The relative economy of airplanes of different sizes has long been a moot question, and is one on which violently different opinions have been expressed by the proponents of various schools of design. It is my belief that the subject has suffered from the excessively frequent introduction of the semi-fallacious square-cube law, and that the investigations of the theory of the effect of size have seldom given the large airplane its due. Experience shows the possibility of increasing the ratio of useful load to total weight as the size is increased, provided only that the weight is distributed along the wings in such a way as to reduce the flying stresses. This is sometimes objected to in military aircraft for military reasons, but there is no valid objection to the use of an efficient distribution of weight in commercial airplanes unless the powerplants are placed in inaccessible locations in an endeavor to distribute their weight. The ideal for the airplane of great size appears to be the cantilever monoplane with the engines arranged in two, three or four groups along the span of a supporting surface thick enough to permit a mechanic to pass inside of it from one powerplant group to another. The general plan is that of the Staaken-built Zeppelin monoplane.

There is another gain in percentage of pay load in that

the proportion of the useful-load capacity which goes into the weight of the chew is less in a large airplane than in a small one. The weight of a pilot must be allowed for in any case, even on a 100-hp. machine; a crew of two, including the pilot, suffices for anything up to 1000 hp., and three men should suffice for double that power. To keep the weight of the crew down to 0.5 lb. per hp., at least 700 hp. must be used if an assistant pilot is to be carried, as is in general wise practice. The very large airplane has the advantage not only in improvement of the weight ratio just noted, but also in the larger amount of space available for the passengers, resulting in more comfortable travel; in the greater safety which results from a multiplication of units and from the installation of radio and other navigating equipment which is too heavy to be carried in a three or four-passenger machine.

The coming of the giant airplane in commerce is prevented only by the lack of public demand for its services. Obviously, however great the saving in unit cost, there is no financial advantage in using machines so large that they cannot be completely filled. It must be remembered that the railroad has a certain advantage over the airplane in that the railroad's operating units are made up of multiple elements and that cars can be attached and detached at will. To gain a similarly variable capacity an air-transport enterprise must either have available machines of different sizes, the choice among them for a given trip depending on the amount of business, or must run small machines and many of them, starting several together at each hour when a departure is scheduled and distributing the load among them instead of carrying the same total amount in a single large airplane. The best plan appears to be to compromise, using machines of two different sizes. One of these sizes should be such that a single machine will take care of the normal traffic on a single trip with about 10 per cent of the seats unoccupied, while the other should be much smaller and held in reserve to take care of overflow demand. The usual practice at present is to run a definite number of machines of fixed size, and the schedule has not been subject to alteration in emergencies except on reasonably long notice. Passages must therefore be engaged well in advance to make sure of securing them.

The system works passably well where the business is largely with tourists, but it will not prove permanently satisfactory for business men. A service ample for emergency requirements must be provided, and for similar reasons the desire to use large machines must not lead to an undue increase of the intervals between trips. One of the fundamental advantages of airplane transport is that, running relatively small units as it does, it can be operated at much shorter intervals than can a limited-train service, and this advantage must not be sacrificed. It can be laid down as a general rule that, on a popular service, the spacing of departures should be about 30 min. for every 100 miles of length of route. The size of machine used should not be increased beyond six or eight-passenger capacity until that frequency of service has been attained, but thereafter any additional requirements of the traffic should be taken care of by increasing the size of the unit. When we have a route on which there is a steady traffic four or five times as large as that which now exists between London and Paris there will be justification for the use of airplanes carrying 30 to 40 passengers each, and they are sure to come. Already, in his report to the French Chamber of Deputies on the current aeronautical budget, M. Bouilloux-Laffont has considered seriously the possibility of bringing into service airplanes carrying 90 passengers each and has given some estimated figures on the probable operating costs of such a giant, showing much lower unit-cost than any present type. The 90-passenger airplane is not by any means at hand at present, but the trend of progress is distinctly in that direction.

Safety

Safety is dependent chiefly on reliability, structural strength, stability and control, fire prevention and the measures taken to reduce the risk of injury to the passengers if a crash should occur. Reliability has already been mentioned. It becomes of increasing importance, from the safety point of view, with increasing ruggedness of the country flown over and with increasing landing-speed of the airplanes. A high landing speed makes it possible to obtain high speed without an unreasonable sacrifice of economy, but it necessarily increases the danger in a forced landing. The only possibility of using really high wing-loadings, where a single powerplant is used or where in general the design is such that sudden forced landings need be considered, arises through the application of some variable-lift device. It is in connection with commercial aircraft, flying over level country, where high speed at an economical angle of attack is desirable and where great climbing ability is not required, that such mechanisms as flap gears and slotted wings are likely to find their greatest usefulness. The total avoidance of forced landings is possible only by the use of multiple powerplants. At least three distinct units must be used to score a real advance in safety. The independence of the units must, of course, be absolutely complete, extending to fuel, cooling and lubrication systems. There is no excuse in present design for the stoppage of one engine to have an effect on any other.

It is not necessary to take up in detail all of the points that contribute to safety, but there are a few which should be emphasized. To prevent fire, either in the air or after striking the ground with violence, the fixtures of the cabin should be made non-inflammable so far as possible, and the gasoline tanks should be supported under the wings or in some other location well away from the powerplant and the passengers. It is practically impossible always to prevent smoking in the airplane, and with the possibility that a match may be lighted at any time by some thoughtless passenger it is hardly necessary to stress the necessity of eliminating gasoline fumes and lace curtains from inside the fuselage. The question of structural strength need not be dwelt upon, for it goes without saying that structural strength should in all cases be sufficient to provide absolute insurance against failure in the air. The methods of calculation now employed are ample to assure safety under the conditions of utilization of commercial aircraft, whatever difficulties may arise in connection with certain machines traveling at very high speed and being violently maneuvered. The only doubtful point at present is the magnitude of the loads to be allowed for, and even these have become fairly well standardized, although it is my belief that fuselages and rear wing-trusses in commercial machines are in general much stronger than the front trusses of the wing cell and are therefore stronger than they need be.

Stability and control, treated as elements contributing to safety, have attracted too little attention in the past. A large proportion of all accidents result from defects in those features, and particularly from the liability of airplanes to fall into a spin when turning with insufficient power. There may be some objection to classing this as a defect, since spinning is an important factor in the maneuvering of military aircraft, but it is certainly de-

sirable that commercial machines should be spin-proof, and if that aim cannot be attained they should at least be free from the danger of falling into a spin without the pilot's desiring it and substantially without warning. The subject of stability is, of course, too involved to bring into a general report of this kind, but I firmly believe in designing commercial aircraft for a very high degree of longitudinal stability, even at the cost of some sacrifice in readiness of response to the control. These machines are not built to be stunted, and indeed they are not strong enough to stand it. There is no necessity for sudden changes of attitude and there is much to be said for designing so that sudden changes of attitude will become impossible. It is not even necessary in the commercial airplane to change the speed of flight or the angle of attack except at long intervals or for very short periods while climbing or descending, and the airplane should therefore be designed and adjusted to trim at the one particular speed of normal cruising and should resist vigorously any attempt on the part of the pilot to make it depart from that normal condition.

Finally, at least so far as safety is concerned, we have always to consider the possibility of a crash and to minimize its evil results. To do that is largely a matter of the proper relative placing of the component parts of the airplane, arranging them so that as much of the structure as possible will break up before the passengers strike the ground in a bad accident, and so that no heavy weight can fall on the passengers or crew. There are two possible methods of accomplishing this, the first being to place the heavy concentrated loads so that they will strike the ground first as the airplane structure begins to break up and will absorb a large part of the energy of shock in so doing. That is the theory of the conventional tractor machine, and experience has indicated it to be the soundest arrangement yet brought forward. Certainly there is no place in passenger-transport service for the pusher machine with the engine behind the passengers. There should be no place, either, notwithstanding the remarkably fine view which they afford, for those multi-engined types in which some of the passengers are in the extreme nose of the fuselage; or even for the arrangement of a tractor machine, now employed on several commercial types, with the passengers directly behind the engine and the pilot at the rear of the cabin. It is the first duty of a designer to guard the safety of the passengers, even as it is the first duty of the pilot to protect those entrusted to his care, and the structure should be arranged so as to give them the maximum of safety.

Since 19 crashes out of 20 take the major part of the impact on the nose of the fuselage, the obvious requirement for safety is that the passengers shall be placed as far back from the nose as possible. The placing of the pilot near the front of the fuselage also improves his field of vision in those regions most important for a commercial machine, forward and downward. Percentages of blind area do not tell the whole story of effective vision by any means. The pilot of a commercial airplane does not need to watch out for attack from the rear, but there should be as little interference as possible with his view in the directions where danger of collision arises. The second theory of design for safety in crashes has as its basis the placing of the crew or some of the passengers in such a position that they will be shielded by some element of the airplane structure when striking the ground. Notable illustrations are found in certain designs where the pilot is placed beside the engine. Although the scheme is one that has worked very well in some particular embodiments it cannot be considered as generally efficacious for safety as the standard tractor arrangement.

[2] See THE JOURNAL, June, 1922, p. 469.

Speed and Comfort

The steps that must be taken to secure speed have already been suggested. I have shown, in a paper entitled Airplane Performance Formulas,[2] that the speed is governed almost solely by the ratio of the wing loading to the power loading. An increase in the speed therefore means either an increase in the wing loading, with a resultant rise in the landing speed and a loss of climbing power, both of which mean decreased safety, or a decreased power loading, which carries with it a direct and inevitable loss of economic efficiency as measured by pay load per horsepower. The result is, as already noted in the introductory paragraphs, that speed will always be kept as low as possible without loss of business to competing transportation enterprises operating on the ground or water. Over the water, operating speed can be cut as low as 70 m.p.h.

Comfort, the fourth and last of the general qualities to be sought, calls with particular force for discussion by writers, for it has unfortunately suffered from neglect by the designers of commercial aircraft as a whole. Comfort in its broadest sense means good seating arrangements, good ventilation and heating if weather conditions require it, satisfactory vision from the cabin and reasonable freedom from noise. Concerning the seating arrangements, it is necessary only to give warning against excessive crowding of the seats and against the use of chairs turned so that the passengers will be facing backward. Air transport must appeal to the ordinary traveler. A fair percentage of such travelers object to riding backward in a train and the sensation is far more unpleasant in an airplane, particularly when diving for a landing.

The problem of ventilation has not been solved at present. When operating in warm weather, it is comparatively easy to secure satisfactory results simply by providing windows that can be opened although, even then, some care in their placing is necessary in order that the opening of a window may not start a gale blowing through the cabin. The windows should always slide and not swing, and it is advisable to have ventilating panels in the top and bottom of the cabin, in addition to the side windows, so that a current of air of any reasonable velocity that may be desired can be forced through and downward to carry off the vitiated air that hangs near the floor. When an airplane is to be operated through the cold weather, the problem becomes much more acute and has not really been solved to date except by the expedient, in itself a confession of failure of the design, of furnishing Arctic clothing to the passengers. There should be no serious difficulty in heating the cabin from a stove on the exhaust, mixing the air taken in across the hot exhaust-pipe and that taken in from the free atmosphere in proportions controllable by the passengers, but if this is done it is necessary to connect the stove on a portion of the exhaust pipe which is perfectly seamless. The major cause of the bitter complaints against the ventilation of the cabin in some airplanes has been the penetration of small amounts of exhaust fumes to the interior.

Elimination of Noise

While on the subject of exhaust disposal and exhaust heating, something may be said of the silencing difficulty, for the exhaust is the principal factor in noise production. While it is perfectly true, as often suggested, that

if the exhaust were eliminated the propeller would still make considerable noise, particularly with high-speed engines, with the propeller directly mounted on the crankshaft, this is no reason for not trying to suppress the exhaust noise. If that is eliminated what remains will be much less unpleasant to the ears of the passengers than was the original sound.

The reduction of noise is not a matter of great difficulty, far though we are from complete silencing. It is only necessary to use a long exhaust-pipe of ample section, preferably somewhat restricted at the end and discharging well behind the passenger compartment, to reduce the noise to a point where conversation during flight becomes practicable. Having taken that step, the only other acoustic precaution that need be emphasized is the necessity of avoiding any vibration of the structure itself or any sounding-board action of the cabin walls, and particularly of the front wall between the cabin and the powerplant. From the standpoint of reduction of high-frequency structural-vibration and so of noise, it is essential that the usual unsupported panels of sheet metal and veneer be reduced to a minimum. Where flat fireproof bulkheads are desired close to the powerplant, they should be made of asbestos in preference to metal. The use of asbestos or other fibrous and non-resilient materials of somewhat lighter weight, such as felt or kapok fiber, has great possibilities for the deadening of sound in the whole airplane, and the designer of a commercial aircraft should give careful attention to the possibility of backing up walls of plywood or light metal with felt or similar padding. It would hardly be possible to build a truly soundproof cabin, but there is nothing prohibitive in the use of a design or a method of construction which will greatly reduce the noise penetrating into the cabin in other ways than through the open windows.

As already noted, comfort can be liberally interpreted to include vision for the passengers, and this depends in part on the window provision and in part on the general layout of the airplane. It is not difficult to secure reasonably satisfactory vision, but the view for several passengers is much interfered with by the wings in the case of a biplane, or of a monoplane with the wing on the bottom of the fuselage. In this respect the parasol monoplane has a tremendous advantage which alone may prove a decisive factor in favor of its use in some cases, particularly when flying over a country of novel and striking topography, such as the Netherlands or the Florida Keys. One of the great attractions of air transport is the excellence of the view obtained of the country over which one flies, and the designer should plan to press that advantage to the limit.

HAND-WORK

CAREFUL observation extending over a considerable period confirms rather than otherwise the opinion that in the average engineering workshop there are still too many hand-fitting or rectifying operations. Obviously, in connection with some classes of work a certain amount of hand-work is unavoidable, as, for example, in the toolroom, particularly in the making of punches and dies. Even on work of this character, however, the provision of a small filing-machine will considerably reduce the amount of actual hand-work required.

In some establishments it is still common practice to mark out castings for jigs and fixtures before milling and boring. This procedure in the vast majority of cases is entirely unnecessary, particularly if discretion and care are exercised in dimensioning the tool drawings so that the milling or boring-machine operator may readily utilize the graduated table-feed dials for setting purposes. A further example of toolroom work, where hand methods might advantageously be superseded by machine work, is to be found in connection with the making of milling cutters, broaches and similar appliances. More particularly in the smaller shops it is by no means uncommon to notice bench-hands spending endless hours filing the relief and rake on the cutting teeth of tools such as those mentioned. Judicious use of the relieving lathe and grinding machine would eliminate fully 75 per cent of this tedious and expensive hand-labor.

Flat-form tools are a further item upon which much time is wasted in most establishments. In this connection it may be taken as a definite fact that by far the greater proportion of flat-form tools, required for any class of engineering production, may be completely finished by milling and grinding, and hand-work such as filing and stoning may be eliminated. Such a procedure, of course, necessitates skilled operators, especially as regards grinding, and here again the drafting room can render valuable assistance by the intelligent dimensioning of drawings.

Regarding ordinary production methods there are innumerable instances in practically every plant where the costs are considerably in excess of what they might be, on account of the employment of an excessive amount of hand labor. The "ritual" of scraping-in crankshaft and connecting-rod bearings is to be noticed in practically every establishment, and absorbs many hours of what is, as a general rule, expensive labor. It is very doubtful whether any scraping-in is necessary. One of the best-known automobile companies in America dispenses with this practice entirely, and after the preliminary machining of the bearings, merely tightens the bearing caps to the desired extent while the engine is being run-in, care being taken to make sure that the bearings under treatment are flooded with oil, to act as both a coolant and a lubricant. If, however, a certain amount of scraping is deemed essential, the operation can be considerably reduced as regards time and expense if the bearings in both the crankcase and the connecting-rod are broached practically to size before the scraping process is commenced.

In many plants it is still the practice first to mill the flat faces, and the flat or the semi-circular ends of the crankshaft webs, and then finish these surfaces by hand-filing. By employing a grinding machine in conjunction with a special form or cam-controlled attachment both the semi-circular or the flat ends, together with the flat sides of the webs, can be finish-ground at one setting, and the time taken is about one-fifth of that required for hand-filing.

Hand-fitting or finishing is undoubtedly the most expensive manufacturing process of all, and in addition to high costs, work produced by hand cannot possibly be on the same interchangeable basis as that produced by machine methods.—*Engineering Production* (London).

Officers of the Society

At the Annual Meeting of the Society held last month, a President; a First Vice-President; five Second Vice-Presidents and four Councilors, three of whom were chosen for the full term of 2 years and one to serve for 1 year only, were elected; and the Treasurer was reelected. In addition to these officers two of the three Councilors elected at the 1922 Annual Meeting and the last Past-President are voting members of the Council for 1923. Such photographs of the officers and Councilors as it was possible to secure are presented on the following pages; and their careers are outlined below.

H. W. Alden

President Alden was born at Lynndonville, Vt., Dec. 20, 1870. He received his technical education at the Massachusetts Institute of Technology, being graduated from the mechanical engineering course in 1893. For the next 2 years he was associated with the American Projectile Co., Lynn, Mass., in the capacity of engineer.

His connection with the automotive industry dates back to 1895, when he became associated with the Pope Mfg. Co., Hartford, Conn., as an engineer on experimental work. When the Pope organization subsequently became the Electric Vehicle Co., Mr. Alden retained his position until 1906. At that time he became chief engineer of the Timken Roller Bearing Axle Co., Canton, Ohio, and 3 years later helped to organize the Timken-Detroit Axle Co., being made its chief engineer and moving from Canton to Detroit. In 1914 Mr. Alden was elected vice-president of this company and last December was made chairman of the board of directors.

In June 1917 he was commissioned a major in the Ordnance Department and was detailed to take charge of the development of tanks. In September of that year he sailed for France to study tank warfare and cooperate with the French and English Governments in the development of tanks. After remaining abroad for 4 months he returned to the United States in January, 1918, to supervise the engineering work of the program that had been worked out abroad. In February of the following year he was discharged from the service and in July, 1919, received the Distinguished Service Medal for representing the United States Government in France and England on tank matters and for the development of new tank-designs.

Mr. Alden was elected to Member grade in the Society on March 15, 1905, and, following the death of the late Henry F. Donaldson in 1912, served as President of the Society for the latter half of that year. He is also a member of the Ordnance Advisory Committee of the Society. He was elected to membership in the American Society of Mechanical Engineers in 1908.

Henry M. Crane

First Vice-President Crane was born on June 16, 1874. He received his education in private schools, with a final year at Phillips Exeter Academy, being graduated in 1891. He was graduated from Massachusetts Institute of Technology in 1895 with the degree of Bachelor of Science in Mechanical Engineering and in 1896 with a similar degree in Electrical Engineering.

After graduating he joined the laboratory force of the American Telephone & Telegraph Co. in Boston and worked there 2 years. In 1898 he was transferred to the engineering department of the Western Electric Co. in New York City, where he worked first on the preparation of telephone switchboard installation specifications and later on the development of apparatus and circuits. In 1905 he left the engineering department to become engineering assistant to H. B. Thayer, general manager of the company, and the following year resigned from the company.

In 1906 Mr. Crane organized the Crane & Whitman Co. in Bayonne, N. J., for the development of gasoline automotive machinery and especially motor cars. This company later became the Crane Motor Car Co., and in 1914 was consolidated with the Simplex Automobile Co. He was president of the Crane Motor Car Co. and vice-president of the Simplex Automobile Co.

In 1916 the Wright-Martin Co. was organized and absorbed the Simplex company. Mr. Crane became vice-president in charge of engineering and remained in this position after the reorganization of the company as the Wright Aeronautical Corporation, about Jan. 1, 1920. He resigned from the latter company in March 1920, and for the remainder of the year was not engaged in any regular business but did some consulting work. During the past year he has been engaged in the development of a new passenger car.

Mr. Crane has taken a prominent part in the work of the Fuel Committee of the Society, and is Chairman of its Research Committee and the Aeronautical Division of the Standards Committee. At the 1920 Annual Meeting of the Society he was elected Second Vice-President representing aeronautic engineering, and was elected a Councilor at the 1922 Annual Meeting of the Society.

A. W. Scarratt

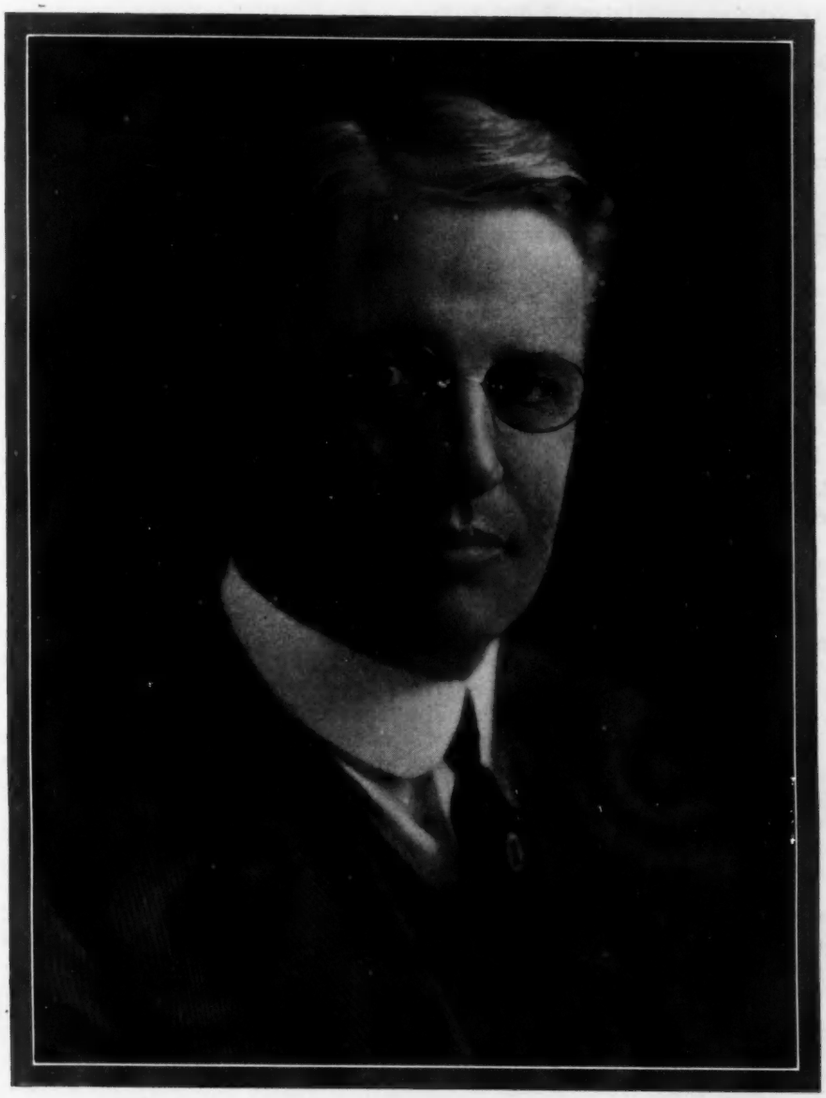
Second Vice-President Scarratt, representing tractor engineering, was born in St. Paul, Minn., April 16, 1886. He received his early education in the public schools there. Later he was graduated from the Mechanic Arts High School of St. Paul after completing the engineering course. In 1905 he was employed by the Twin City Rapid Transit Co. as a draftsman in the mechanical engineering department, where he was engaged in the design of car bodies and rolling stock of all kinds for approximately 4½ years. He was then transferred to the power and electrical department, where his work consisted of powerhouse layouts and reconstruction work and sub-station design; and was later made assistant foreman at the shops of the company. While with this company he attended the University of Minnesota for 3 years.

In 1913 Mr. Scarratt accepted a position in the tractor engineering department of the Minneapolis Steel & Machinery Co. He has been prominently identified with the development and production of the line of tractors built by this company.

He was elected to membership in the Society in 1915 and was vice-chairman of the Minneapolis Section in 1920. He was elected a Councilor in 1920.

A. F. Masury

Second Vice-President Masury, representing motor-car engineering, was born at Danvers, Mass., in 1882. He was graduated from Brown University in 1904 with the degree of Mechanical Engineer, and became associated with the General Electric Co. at its Lynn, Mass.,



H. W. ALDEN

plant in the building of heavy-duty electrical machinery. The following year marked the beginning of Mr. Masury's connection with the automotive industry, as at that time he was retained as engineer by the Vaughn Machine Co., Peabody, Mass., which was engaged in the development of two radically different motor-vehicles, the Gaselec passenger-car which had a magnetic clutch, and a steam motor-truck modeled along the lines of the Coulthard vehicle that was being built in England at that time.

In 1907 Mr. Masury became shop foreman and engineering assistant for the Hewitt Motor Co., which at that time was building 10-ton trucks in New York City. He was subsequently sent to Brooklyn to superintend the construction at a plant there and was made assistant chief engineer of the company in 1908. When the International Motor Co. was formed by the consolidation of the Hewitt Motor Co., the Mack Bros. Motor Car Co. and the Saurer Motor Co., Mr. Masury was made New York City service-manager and shortly afterward was engaged in the selling in the New York territory of the trucks built by this organization. In 1912 Mr. Masury was appointed chief engineer of the International Motor Co., and was elected to serve as its third vice-president in 1918.

Mr. Masury was elected to Member Grade in the Society in 1908.

E. P. Warner

Second Vice-President Warner, representing aeronautic engineering, was born in Pittsburgh, on Nov. 9, 1894. He was educated at the Volkmann School, Boston, and after being graduated from Harvard University with the degree of Bachelor of Arts in 1916, attended the Massachusetts Institute of Technology, receiving the degree of Bachelor of Science in 1917 and that of Master of Science in 1919.

During the war he was employed as aeronautical engineer for the Air Service in connection with research and also as instructor in the military course in aeronautical engineering at the Massachusetts Institute of Technology. From January 1919 to June 1920 Mr. Warner served the National Advisory Committee for Aeronautics as chief physicist, directing aeronautical research work at Langley Field; and for 3 months after that time he continued with the Committee as acting technical assistant in Europe. Since the fall of 1920 he has been associate professor of aeronautical engineering at the Massachusetts Institute of Technology.

He was elected to Member grade in the Society in 1917. Professor Warner is also a member of the American Society of Mechanical Engineers, the Society of Naval Architects and Marine Engineers, the American Physical Society, and an associate fellow of the Royal Aeronautical Society. He has been sole or joint author of about 40 published reports and papers, one of which, Airplane Performance Formulas, was presented at the 1922 Semi-Annual Meeting of the Society.

L. W. Witry

Second Vice-President Witry, representing stationary internal-combustion engineering, was born at Waterloo, Iowa, March 28, 1870. In 1884 he became an apprentice in a railroad shop and followed the machinist's trade for 13 years. His experience in that period covered all branches of machine work as it is performed by railroads, including machine and erecting shops, roundhouse work, valve-setting and adjusting airbrakes.

Mr. Witry's connection with the automotive industry dates back to 1897 when he became associated with the Waterloo Gas Engine Co., Waterloo, Iowa, as a machinist. After serving in that capacity for 5 months he was placed in charge of the engineering work and of the factory of the company, subsequently being made a member of the firm and holding the office of vice-president and chief engineer. When the Waterloo company was purchased by Deere & Co. in March 1918, Mr. Witry was continued as vice-president and chief engineer and has held these positions ever since.

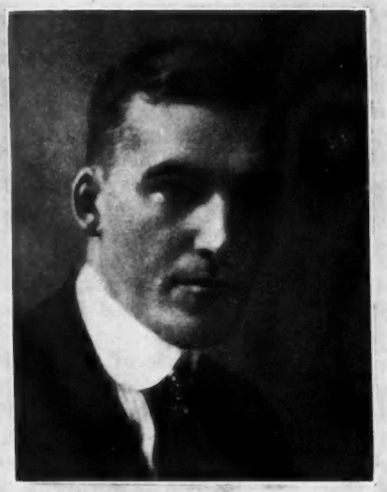
Mr. Witry was elected to Member grade in the Society April 17, 1917.

E. J. Hall

Second Vice-President Hall, representing marine engineering, was born at San Jose, Cal., April 30, 1882. He received his education in the night schools of San Francisco and took a steam engineering course in the International Correspondence Schools, becoming a steam engineer in the employ of the irrigation plants in the Santa Clara valley at the age of 16. Subsequently he learned pattern-making, foundry and machine-shop practice in the shops of San Francisco and while in the service of the I. L. Burton Machine Works of that city began the design of marine and hoisting engines and various kinds of gas engine.

In 1902 Mr. Hall was given a half interest in the Burton company and in the following year began building hill-climbing automobile engines to replace those in the cars being shipped to the Pacific coast. This marks the beginning of his association with the automotive industry, as he then specialized in the production of commercial automobile engines; in 1905 he became associated with the Heine-Velox Co., a builder of complete automobiles. The plants of both this company and the Burton organization were destroyed in the earthquake and fire of 1906 and Mr. Hall took charge of a large mechanical school. In 1907 he became designer and manager for the Comet Automobile Co. Later he opened an independent repair-shop and factory and built a car of his own design which bore the trade name of the Comet. In 1909 he, together with Bruce Kennedy, organized the Hall-Kennedy Works and a year later with B. C. Scott organized the Hall-Scott Motor Car Co. to build industrial locomotives, gasoline-driven railroad coaches, interurban electric-car bodies and automobile and aviation engines. Since the organization of this company Mr. Hall has been first vice-president and factory manager.

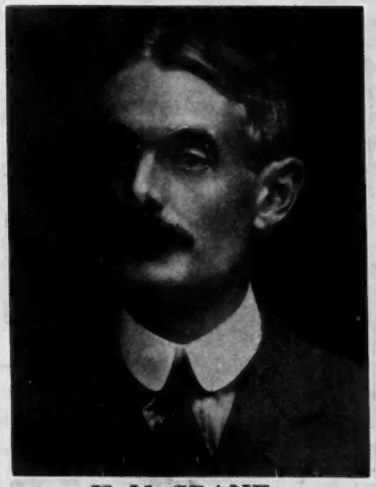
In 1913 four and eight-cylinder Hall-Scott aviation engines were flown successfully in America and the company supplied engines to numerous airplane companies that were beginning to spring up all over the Country at that time. Two years later the company designed and perfected a six-cylinder aviation engine which was sold to the Government of the United States and several foreign countries, large numbers being used by the Allies in the European War. Together with Past-President Vincent, Mr. Hall is entitled to the credit for designing the Liberty engine, having been invited in May 1917 by Col. E. A. Deeds of the Aircraft Production Board to collaborate with Mr. Vincent in the design of a new all-American aviation engine. The part played by both of these members in the development of this engine was given in the paper by Mr. Vincent entitled the Liberty Aircraft Engine that was presented at the 1919 Annual Meeting of the Society. Mr. Hall remained in the City of Washington as consulting engineer for the Aircraft Production Board and when the equipment division of the Signal Corps was formed in August 1917 he was



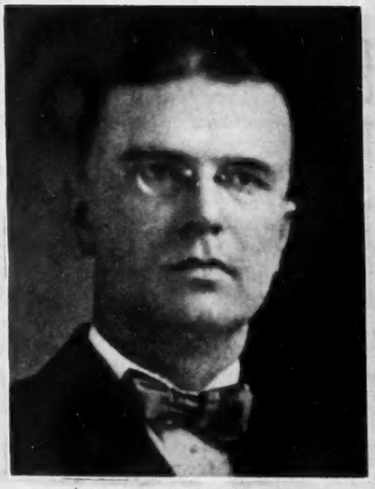
E. J HALL

A. F. MASURY

A. W. SCARRATT

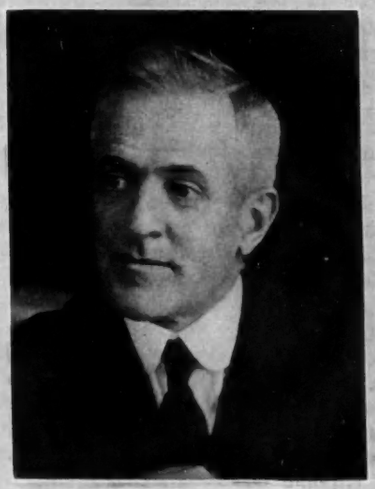


H. M. CRANE



L. W. WITRY

E. P. WARNER



C. B. WHITTELSEY

placed in charge of the production and engineering of the 8- and 12-cylinder Liberty engines and spent several months in organizing eight plants throughout the Country for quantity output.

He was commissioned major in the Signal Corps in October 1917 and in February 1918 was asked to perfect the construction of airplanes and equipment and speed up the production of the DeHaviland and Bristol airplanes which were urgently needed at the fighting front. Major Hall was promoted to the rank of Lieutenant Colonel in April 1918 and went to France the following July as a member of the Lockhart Aviation Mission at the request of General Pershing. After making a complete report of conditions at the front he was appointed chief of the technical section of the Air Service in France on Oct. 17. "For exceptionally meritorious and conspicuous service rendered in the designing of the Liberty engine and subsequently in the adapting of the LeRhone engine to the American methods of production and also in pushing to completion the American adaptation of the DeHaviland plane," Mr. Hall was awarded the Distinguished Service Medal. He was elected to Member grade in the Society on March 14, 1917.

W. A. Chryst

Councilor Chryst was born in Dayton, Ohio, Oct. 21, 1877. His early education was received in the public schools of his birthplace and also in the night schools conducted by the Young Men's Christian Association.

In 1892 he became associated with the National Cash Register Co. and served in various capacities, having charge of one of its inventions departments in 1911, when he became chief engineer of the Dayton Engineering Laboratories Co. Mr. Chryst has been engaged since 1909 in the design of electrical equipment for automotive purposes, including the earliest types of starting, lighting and ignition apparatus developed by the Dayton company.

He was elected to Member Grade in the Society on July 29, 1912. Since January 1917 Mr. Chryst has been a member of the Electrical Equipment Division of the Standards Committee and served as one of the Vice-Chairmen of the Committee in 1921.

F. W. Gurney

Councilor Gurney was born April 21, 1867, at New Braintree, Mass., and was educated at Oberlin College, being graduated therefrom in 1891 with the degree of Bachelor of Arts. After leaving college he invented a machine for turning out wooden bowls which were and are still being manufactured by the Gurney Mfg. Co. in the South. Shortly after this Mr. Gurney invented a wood split pulley that was also produced by this company.

His connection with the automotive industry dates back to the winter of 1900 when he went to Jamestown, N. Y. The following summer he became interested in ball bearings and in the fall of 1903 organized the Gurney Ball Bearing Co., of which he is chief engineer.

Mr. Gurney was elected to Member grade in the Society Sept. 10, 1917.

A. J. Scaife

Councilor Scaife was born in England in 1875 and 5 years later came to America and settled with his family at Cleveland. His early education was received in the grammar and high schools in the vicinity of Cleveland. In 1895 Mr. Scaife's business career began as an apprentice in the toolroom of the A. L. Moore Co., Cleveland. In the fall of 1897 he attended college and the following summer returned to the toolroom of the stamping department of the Cleveland Machine Screw Co., which had succeeded the Moore organization.

In the fall of 1899 he was employed by the Parish & Bingham Co., Cleveland, as a toolmaker and in November of the following year entered the service of the White Sewing Machine Co. as a toolmaker in its automobile department. In the spring of 1901 Mr. Scaife was transferred to the testing department and later to the drawing-room and experimental department where he remained until 1907 when the name of the organization was changed to the White Co. For the next 7 years he was employed in the engineering department of the White Co., having charge of the testing and carbureter departments and also doing some development work. From 1918 to 1921 Mr. Scaife was consulting engineer for the White Motor Co., which was organized in 1914 to succeed the White Co. Since the fall of 1921 he has been factory service engineer in charge of field service for this company.

Mr. Scaife was elected an Associate of the Society on Dec. 23, 1910, and was transferred to Member grade Oct. 1, 1911. He served as a member of the Truck Division of the Standards Committee from 1918 to 1921 inclusive and was Vice-Chairman of the Division last year. When the Cleveland Section was organized in 1915 Mr. Scaife was elected its first treasurer and was chairman of the Section for the year 1916-1917.

H. M. Swetland

Councilor Swetland, who is also the first charter member of the Society, was born in Erie County, Pa., Nov. 15, 1853. The following year his parents moved to western New York where he received his education in the village school and subsequently taught the schools of small villages for 10 years, beginning in 1871.

In 1881 Mr. Swetland entered the publishing business and 3 years later became interested in the steam-engineering journal, *Power*. A few years later he became proprietor of this periodical which he published until its sale to John Hill in 1902. At that time he entered the publishing field of the automotive industry. He founded and established *The Automobile*, now *Automotive Industries;* and promoted *Motor Age, Motor World, The Commercial Vehicle*, and other publications in the automotive field.

Mr. Swetland was the first to foresee the necessity of cooperation among the engineers in the automotive field and through his individual efforts the Society of Automobile Engineers, as it was known at that time, was founded in 1905. It was due chiefly to his efforts that the Society was promoted to sufficient standing to warrant the selection of an active head and he was one of four to finance the Society through its development period. Since the formation of the Society he has served continuously as Chairman of the Finance Committee.

C. F. Scott

Councilor Scott was born at New York City on May 30, 1886. He prepared for college at the Haverford School, Haverford, Pa., for 4 years, and was graduated from the mechanical-engineering course at Haverford College in 1908.

Following his graduation he entered the service of the Sprague Electric Works in the engineering department. After serving 1 year as a designing engineer he was appointed commercial engineer of electric motor and control applications. He has been identified with the de-

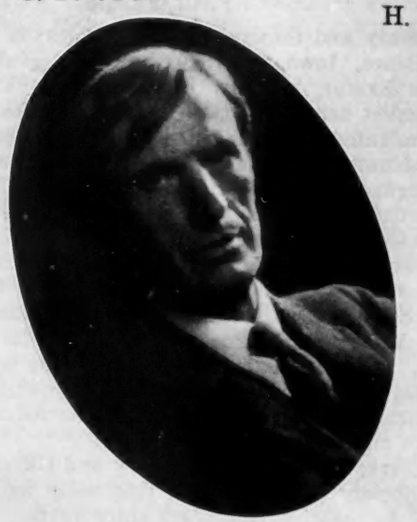
LON R. SMITH

A. J. SCAIFE

C. F. SCOTT

H. M. SWETLAND

B. B. BACHMAN



F. W. GURNEY

W. A. CHRYST

velopment and application of the electric dynamometer almost from its inception in 1909. In connection with his work on dynamometers Mr. Scott specialized for some years in the adapting of the electric dynamometer to testing automobile engines by a thorough study of the internal-combustion engine. He developed and installed the first electric dynamometer for testing a complete automobile chassis. Mr. Scott is now manager of the Sprague Apparatus Products Section of the General Electric Co.

Mr. Scott was elected to Junior grade in the Society Oct. 24, 1911, and was transferred to Member grade Sept. 11, 1912. He was elected Chairman of the Metropolitan Section in 1918 and became Vice-Chairman the following year. He was a member of the Society Nominating Committee, representing the Metropolitan Section, in 1918 and 1919, and was secretary of the Committee in the latter year, and a member at large of the 1920 committee. He has been a member of the Meetings Committee of the Society since 1919 and served as chairman of the Committee in 1921 and 1922.

Lon R. Smith

Councilor Smith was born at Brownsburg, Ind., Dec. 24, 1876. After being graduated from high school, he spent 4 years at pattern-making and 3 more at die-sinking. Since entering the service of the Motsinger Device Mfg. Co., Pendleton, Ind., as superintendent in 1903, Mr. Smith's experience has been confined to the development of ignition, carburetion and engines. In 1907 he became superintendent of the magneto factory of the Henricks Novelty Co., Indianapolis, and from 1908 to 1910 was a salesman for that organization.

In March 1910 he was appointed Western representative of the Eisemann Magneto Co. and as such represented it in all of the United States west of Buffalo with the exception of Michigan and Wisconsin until the fall of 1916. At that time he became sales manager of the engine department of the Buda Co., Harvey, Ill. He left that company in June 1919 to accept the position of vice-president, directing sales and advertising, with the Midwest Engine Co., Indianapolis, resigning in the fall of 1921 when the company was reorganized.

Mr. Smith was elected to Member grade in the Society on June 12, 1911, and was Chairman of the Indiana Section in 1915 and 1916, and was reelected Chairman in the spring of 1921. He was elected Treasurer of the Mid-West Section in 1918 and Vice-Chairman of the Indiana Section in 1922.

B. B. Bachman

Past-President Bachman was born Oct. 4, 1886, educated at grammar school, night school and under a private tutor, and started his business experience in 1900 as a tracer. The next 10 years were spent as tracer, detailer and designer with the Enterprise Mfg. Co., and the Falkenay Sinclair Machine Tool Co., both of Philadelphia, and the Autocar Co., Ardmore, Pa. His entire automobile experience has been with the last-named company, which was a builder of passenger vehicles until 1912 and has constructed commercial vehicles from 1907 to date. Starting with this company in February 1905, he became assistant engineer in 1909 and engineer in 1914.

Mr. Bachman was elected a Junior member of the Society in 1910 and transferred to Member grade in 1912. He is a member of the American Society of Mechanical Engineers, American Society for Testing Materials and the Institution of Automobile Engineers. When the Pennsylvania Section was organized he was one of the charter members and served as its first secretary. He was identified with the work of the Truck Standards Division in 1911 and was Chairman of the Standards Committee from 1918 to 1922. At present he is a representative of the Society on the American Engineering Standards Committee. He was elected to the Council in 1916 and again in 1918. In 1919 he was First Vice-President of the Society, and in 1921 Second Vice-President representing motor-car engineering. As a member of the Truck Standards Division Mr. Bachman participated in the formulation of the specifications for military trucks for the Quartermaster Department, and afterwards was engaged at irregular intervals in the design of Class B and Class A military trucks. In connection with the last named, he was chairman of the committee on design.

At the 1913 Annual Meeting Mr. Bachman presented a paper entitled Comparative Results with Solid and Pneumatic Tires on Light Commercial Vehicles, and at the 1914 Annual Meeting he treated the subject of Double-Reduction Live Axle. At the 1919 Motor Truck Meeting he gave an address on Pneumatic Tires for Trucks.

Charles B. Whittelsey

Treasurer Whittelsey has been connected with the Hartford Rubber Works Co. since 1901, beginning as its purchasing agent. In 1905 he was made assistant to the general manager, in 1906 superintendent, in 1911 secretary and factory manager, in 1915 vice-president and factory manager, and in 1916 president and factory manager. He has served as president of the Hartford Chamber of Commerce and of the Hartford County Manufacturers' Association.

Mr. Whittelsey was elected to Member grade in the Society in 1910. In 1916 he was elected a Life Member. He was a member of the Standards Committee for several years, beginning in 1911, and served as chairman of the Tire and Rim Division in 1918 and 1919. Mr. Whittelsey was a member of the Council in 1912 and 1913, and was elected Treasurer in 1918 and reelected each year since. At the 1912 Annual Meeting he delivered a paper on Solid Motor Tires, and at the 1915 Annual Meeting presented a paper entitled the Pros and Cons of Tire Inflation.

C. F. Clarkson

Secretary and General Manager Clarkson was born at Des Moines, Iowa, in 1870, and was graduated from Phillips Exeter Academy in 1888. In 1889 he was in Government service in the Post Office Department. He was graduated from Harvard College in 1894, pursuing post-graduate work there for the next 2 years. He was next engaged in connection with the installation of an underground telephone system in Philadelphia for 2 years, after which time he moved to New York City and spent several years in work on technical, legal, patent, laboratory and automobile subjects. From 1905 to 1910 he was connected with the Association of Licensed Automobile Manufacturers, as secretary of its Mechanical Branch, publicity manager and assistant general manager. During this time he was the editor of the A.L.A.M. Mechanical Branch Bulletins and of the A.L.A.M. weekly digest of current technical literature.

Mr. Clarkson has been Secretary and General Manager of the Society of Automobile Engineers and of the Society of Automotive Engineers since 1910.

During the war Mr. Clarkson was associated with the Council of National Defense, and served as a member of the automotive products section of the War Industries Board and of the International Aircraft Standards Board.

Presidential Address of B. B. Bachman

IT has become, through custom, a duty for your president to give you at the Annual Meeting an account of his stewardship for the year. In many respects, this is a most difficult task. The opportunities for constructive effort are legion but, unfortunately, one cannot help but feel, when a backward view is taken, that most of them were allowed to pass by unnoticed. Viewed from the beginning, a year seems a reasonably long time; but in retrospect it seems like the "tale that is told."

The purpose of the Society, as outlined in the Constitution, "is to promote the Arts and Sciences connected with Engineering and Mechanical Construction of Automotive Apparatus." There are apparently many ways in which this purpose can be furthered, but for one reason or another many of them fail in practical application, although they are theoretically most attractive and promising. It is a sad commentary on the vaunted mental capacity of humanity that progress is almost entirely a process of trial and error, and only to a very limited degree the result of thorough analysis.

Society Meetings

Recognizing this fact and realizing that individual experience varies, as well as the analysis of experience and the interpretation of results, it can be accepted that one of the most effective ways in which we can further our object is to provide for meetings in which experience can be related, facts reported, theories advanced and, by discussion and criticism, errors in deduction pointed out and stimulus given for renewed effort. It seems to me that such a conception indicates that a large part of the benefit to be obtained is through the reaction of the group on the individual. It is my belief that these facts are not so generally appreciated as they should be, and it is for this reason that a greater attendance at and participation in meetings are difficult to attain. At the same time, we must not lose sight of the fact that there is such a multiplicity of meetings that it becomes exceedingly difficult at times to decide which should be attended and which may safely be let go.

The meetings held during the year, including the meetings of the Sections, have been most diversified as to topics and cannot have failed to contain something of value and interest to anyone connected with the industry. In spite of all this, there seems to be a peculiar apathy on the part of many that results in a small attendance at and a limited participation in these meetings. The lack of support on the part of those most intimately connected with the engineering side of the industry has been the cause for much concern to the Meetings Committee and the Council.

For some years, there has been talk of holding the Annual Meeting in the Middle West on the ground that it is more central for the large proportion of the members. It is, of course, necessary to hold at least the business meeting in the State of New York, but it is possible that it might be well to have only a single-day's session here and then hold sessions at a later date in one of our Western cities. The Meetings Committee has also advanced the thought that an additional meeting in the spring, to be held in the West, would be in keeping with the essential expansion of activities and afford an opportunity for discussion that, by reason of the lack of time, cannot be provided for in either our Annual or Summer Meetings. This is especially true, since the Summer Meeting in recent years has come to be devoted to a considerable extent to recreation. This fact has become the subject of adverse comment and criticism that, I think, is, in large part, unfounded. It is to be regretted, however, that we do not have engineers participate in these meetings to a greater degree. The fact that technical sessions do not fill the entire time is no indication of the possible benefit to be derived. There are few, if any, other opportunities during the year to get together for private discussion and exchange of experience. It is a mistaken conception that the value of a meeting is to be measured by the number of papers with titles breathing importance and text bristling with mathematical symbols.

Engineering is a vocation that has suffered too long from ingrowing thought. We need to develop our capacity for knowing each other and our fellow men so that we may bring to our work a knowledge of a broader thought than that which has to do with technicality alone.

Production Session

A year ago, when I looked forward to the work of 1922 and looked back on the records of my predecessors, I was hopeful that this administrative year would contain some landmark that would distinguish it. I am therefore very proud that, in addition to the general high character of the meetings of the year, it should have been during the year 1922 that the first Production Session of the Society was held. This pride is not personal, but is a satisfaction felt in the accomplishment of the chairman and members of our Meetings Committee, assisted by several of our members in Detroit, who conceived this idea, and developed and carried it to such an eminently satisfactory conclusion. The results of that meeting were such as to stimulate activity and the thought of conducting more meetings of this character in the future.

There is, however, one idea which arose as an outgrowth of this meeting that it will be well for all of us to stop and consider seriously. What I have reference to is the thought that the success of this meeting indicates the need for a production engineers' section. While there are many sound arguments in support of this proposition, I wish to submit for your consideration the view that division in our work as a society may be undesirable. This organization was originally the Society of Automobile Engineers, and when this title was changed to the Society of Automotive Engineers, it was not with the idea of producing a confederation of groups of individuals, but to provide a union in which engineers engaged in the arts and industries founded on the internal-combustion engine could cooperate. Has this union as yet been completed? Is it not true that the truck engineer scans our programs and, if he does not see titles that he conceives to be of direct interest in his labors, refuses to attend particular meetings? The same is true of the engineer engaged in aviation, marine engineering or any of the other classifications. I am convinced in my own mind that we should do everything in our power to eliminate this idea of classification. We are all suffering from the handicap of a limited horizon and it is one of the prime functions of an organization such as ours to furnish a greater breadth of perspective. This cannot be accomplished by individualistic effort.

The success attending the Production Meeting arouses

in my mind the hope that we shall in some way find the means to bring the meetings dealing with the problems of service onto the same plane. Here again is a field in which the engineer is most interested, whether his immediate activities be along the lines of design, production, sales or service. It is my hope that it will be possible to organize such meetings as definitely to convince individuals engaged in all of these lines that they cannot afford to miss them.

The Sections

While it is unnecessary to emphasize the value to the Society resulting from the activities of the Sections, nevertheless the proper organization and regulation of the Sections to insure the obtaining of the greatest good to the greatest number has been from the beginning and continues to be a most vexing problem in many respects. The present healthy condition of the Sections and the valuable contribution they have made to the Society's work is a tribute to the loyalty and devotion, as well as the hard work, which the Sections Officers and Sections Committee have given.

The question of financing the Sections to permit their reasonable growth and furnishing those services to the local membership of the Society that are desirable is most difficult. Up to this time, it has been impossible to reach an agreement that complete support of the Sections' activities should come from the Society funds, although this viewpoint has been presented most earnestly by several of our Sections officers. While I appreciate the force of the arguments that have been advanced in favor of this idea, I am fearful that the adoption of such a policy, attended, as it most probably would be, with a more strict supervision of the Sections' work by the officers or the headquarters staff of the Society, would result only in an undesirable restriction of the initiative of the local organizations which would inevitably affect their efficiency adversely.

In short, it is my belief that the Sections should be given the largest amount of freedom possible in the conduct of their affairs. This freedom of action, of course, carries with it certain responsibilities and obligations which, if accepted and faced, will result in a stronger and more effective organization than one that is fostered and supervised more closely by the Society.

Society Membership

During the past year, as I reported to you at the Summer Meeting, we have been faced with the matter of a considerable number of resignations, together with the necessity of dropping a number of members due to nonpayment of dues. While it might be considered that this condition, in large part, was due to the unsettled industrial conditions, with the consequent inability of a number to keep up their membership, it was felt that it was worthy of considerable study to determine whether by any chance a misunderstanding on the part of the individual as to the value of the Society's work or a lack of proper service on the part of the Society to the individual might be responsible.

To investigate this matter, Past-President Beecroft was appointed chairman and given authority to organize a committee. As a result of their study and recommendation a large number of names have been eliminated from our rolls by resignation and removal, which number approximately balances the new members received and leaves the total membership of the Society at this time about where it was a year ago.

While this loss is regrettable, the total showing, in view of the conditions we have faced, is not altogether discouraging. During the past 5 years we have passed through a period when many men entered the industry or allied lines through war work and joined the Society. The subsequent contraction affected many and made it necessary for them to go into other fields where they no longer felt an interest in our activities or could not be benefited by them. This condition seems to have been inevitable and natural, and largely explains the membership losses mentioned.

From the standpoint of numbers and the representative character, the membership of the Society is most satisfactory. If the time ever existed, it has passed, when we had to approach prospective members on the basis of our need of them. The development of the organization has produced a variety of services and a fund of experience in doing things that will provide something of value to any man, and it is time we all recognize this fact and proceed to act accordingly. Recognizing this, we must still realize that there are many men who should be members, and that not in name only, but in a most active capacity. Reference has already been made to the production engineer and the service engineer; both should be more prominent in our membership. We could afford to spend much more time than we do in considering so-called production and service problems. I have never been able to understand the opinion that separates these factors from the field of engineering. Rather, it is to be regretted that we do not have abler discussions of phases of these subjects that are presented to us from time to time.

Classification of Members

In connection with the matter of membership, there is one consideration that I believe merits careful thought. At the business session in June we had considerable discussion on the subject of classification in Member and Associate grades. While I believe in the essential soundness of the policy which recognizes that a difference in qualifications, based upon training, experience and occupation, coupled with an active interest in the aims of the Society, can be provided for most suitably by a division of the membership into classes. I am not certain that the present method of classification is the best possible. Furthermore, I am inclined to feel that, while this is an organization of engineers, and as such should be controlled and managed by and for engineers, it may be wise to stop and consider what in future will be the problems arising out of a large body of members with no voice in the affairs of the Society.

Time was when the Associate had equal power of suffrage with the Member, and modification of the constitutions of several of our sister societies has instituted this feature recently. Whether such a step is wise, is at least open to question, but the fact remains that the situation calls for study and careful consideration.

Research

The work of the Research Department has gone forward in a most satisfactory way, and the Committee and the Manager are to be congratulated on the manner in which the foundations of this work have been laid. Undoubtedly, you have all noticed in recent months the contributions to The Journal which have been made by the department; these should become of greater and greater value as time goes on and the work becomes more firmly established.

One very gratifying result of the activity of the Research Department has been the cooperative investiga-

tion, under the auspices of the American Petroleum Institute, the National Automobile Chamber of Commerce and the Society, conducted by the Bureau of Standards in the matter of determining the effect that a variation in volatility of fuel has on its general usefulness in existing types of motor vehicles. Some of the results of this work have been published, and more of them will be outlined during this meeting. The data reported should go far toward giving the representatives of the petroleum and the automotive industries a basis for discussion.

A valuable by-product of this work has been the broader viewpoint and more general familiarity of the other fellow's problem that the association of representatives of the two industries has developed.

Finances

With regard to the financial condition of the Society, I feel that the report of the Treasurer can be considered most satisfactory. It is, of course, to be regretted that conditions were such as to make a deficit in the operating account unavoidable. However, it is gratifying that the anticipated deficit which we faced at the beginning of the year, was reduced by approximately one-half at the end of the fiscal year.

The outlook for the new year is most promising. The Finance Committee in estimating the budget has presented to the Council a report, which was accepted, indicating that, without a reduction in the activities of the Society and with only a reasonable increase in revenue from membership and publications, it will be possible to make income and expense balance. In the light of the general industrial conditions during most of the past year, I feel that this condition is highly encouraging.

Finally, I wish to thank you all for the charity with which you have received my efforts during the year, and for the support that has been given by the Council, committees, members and the General Manager and his staff. The duties of the office are becoming difficult and exacting and, while I have appreciated greatly the honor accorded me in selection for the office, and though the work has contained many elements of satisfaction, it is only honest to confess that I am viewing the end of my responsibilities with a feeling of relief.

With this in mind, I want to bespeak for the one you select as my successor the same cordial support which alone has made it at all possible for me to carry-on this year.

SIMPLIFICATION

THE American Engineering Standards Committee has requested assistance in the canvass its cooperating bodies are making at the request of Secretary Hoover, of the Department of Commerce, for suggestions in regard to subjects in which there is a need for industrial simplification through a reduction in the number of styles, sizes and cataloged lines. In the opinion of the American Engineering Standards Committee, engineers and industrialists can render a notable service to American industry by making such an analysis of the needs of industry.

Reference is made to the importance of the economic losses involved in non-standard manufacture and an unnecessary variety of styles, types and sizes of staple materials, products and processes, and suggestions are called for from the standpoint of the members as technical and professional men, whether as producers, designers, consultants, buyers, fabricators or final consumers, or as members of the great body of general consumers. The form given below is provided for this purpose, which it is requested be filled out and mailed to the office of the Society.

The more specific the suggestions are, the more effective they will be in helping to bring about active work on definite projects, and, through this, actual concrete results introduced into the industries.

Subjects for Simplification and Standardization

Inquiry made by the Society of Automotive Engineers, Inc., at the request of Secretary Hoover and the American Engineering Standards Committee

(1) In what raw materials or manufactured products do you believe a reduction in the number of styles, sizes, grades or cataloged lines would bring about economy in purchases, production, distribution or selling?

General Subject .....
Specific Items .....
.....
.....
General Subject .....
Specific Items .....
.....
.....

(2) In connection with what subjects or items do you think the Society of Automotive Engineers should take an active part, as an organization, in bringing about such simplification or standardization?

.....
.....
.....

Signature.....
Business Address.....
.....

Please include explanations and further suggestions on a separate sheet. Such "background" will be helpful.

Questions Answered by the Research Department

MANY of the inquiries answered by the Research Department are of much general interest and involve a considerable amount of thought and research. For the information of our members a few of them will be published each month. It is hoped that in this way those members who have not yet availed themselves of the facilities offered by the Research Department may be encouraged to take advantage of them in the future.

PISTON-RING CLICK

A LETTER was received from a company handling repairs and replacements, describing some of its experiences with the phenomenon of piston-ring tick or click, stating some observations, and asking for further information on the subject.

Copies of the letter were sent to a number of engineers, with a request for their views. The following extracts from replies received illustrate the divergence of opinion on this question:

My experience with the click in piston-rings is that it is due to their being fitted with too small a gap. Piston-rings, generally speaking, should not be fitted with less than 0.015-in. gap. I believe that, if this amount of gap is used, the click will disappear.

We have had considerable experience with this condition. In every instance, so far as we have been able to determine, the click was caused by insufficient clearance between the ends of the piston-rings.

We have carefully checked-up the matter on brand new cylinder-blocks and pistons, as well as on worn blocks. The same condition will exist in either of these if there is insufficient clearance. Just what is brought about to cause this noise, we are unable to determine definitely, but we have yet to find a case which we have been unable to correct by slightly relieving the ends of the piston-rings.

We believe that this noise is caused by insufficient clearance between the ends of the ring, causing the ends to strike together at the beginning of the firing stroke. In our own experience the noise has usually developed with diagonally cut rings where it is necessary to hold the clearance rather closely.

At various times we have tried filing notches in the upper groove to let the compression in behind the ring, but with a step-cut ring we do not believe that this action is required; we have had no trouble with rings of this type. Our difficulties have not been serious, and for this reason our tests have not been extensive enough to develop any exhaustive conclusions.

We have found that piston-ring tick will occur when the ring bottoms circumferentially at its split, due to being fitted too closely. Excessive over-travel in the cylinder bore can also be expected to give a similar result. These two seem to us to be the most prevalent sources of the condition.

Whatever noises there were in an engine, I have laid to other causes than piston-rings. Of course, worn or poorly fitted rings may cause a click in shifting from one side of the groove to the other, but I believe that correctly fitted rings, with a clearance of, say, not over 0.0005 in., and the clearance cushioned with an oil-film, should remain perfectly silent.

I have experienced piston-ring click on large-bore jobs with rather flexible rings. It was apparently caused by the pressure collapsing the ring until the ends struck. Running the bottom of the groove close to the back of the piston-ring will help the situation. Notching the top of the ring, to let the firing pressure back of the ring, will also relieve the situation, but will make the ring only partly effective as a seal.

I think it is obvious that the trouble develops only where there is considerable clearance between the ends of the ring, as this condition would be necessary to get enough travel to produce the noise. We have never had this trouble where the rings had joint openings just sufficient to take care of expansion, and the groove was not too deep.

In several instances of severe piston-ring click, it was found upon examination that the top ring on the piston projected above the bore of the cylinder at the end of the stroke so that this ring was subjected to the explosion pressure on the outside, thus collapsing the ring and causing an unusually loud click. This trouble was cured by increasing the length of the cylinder bore so that the ring would not project above it, and diminished in some cases by relieving the top face of the ring to allow the explosion pressure to get behind ring and keep it tight against walls of the cylinder.

More frequently, however, this trouble has been encountered in service where the pistons fitted loosely in the cylinders or the cylinders had become tapered, being larger at the top and causing the same effect as loosely fitting pistons. In such cases the piston will rock, causing the oil-film between the ring and the cylinder-wall to be weakest at the top on one side of the piston, so that any appreciable explosion pressure would have a tendency to collapse the ring, in some instances causing a remarkably loud click and even piston slap.

In other cases, the click has been due merely to the ends butting; and is very indistinct. The most notable click, however, is caused by the collapse of the ring. It was found in several instances that the explosion blew-by all of the rings and could be noticed in the crankcase very easily.

Of course, shoulders in cylinders, tapered bores and dry spots due to faulty lubrication can cause piston-ring click. There are, however, cases in which the sound remains after every possible chance of defective installation is removed.

Some time ago we had a great many complaints as to Ford installations on this score. Since then we have increased the radial thickness of our standard Ford-size ring, with the result that the trouble has been entirely eliminated.

The obvious explanation of the sound is that when the pressure rises suddenly in the cylinder the pressure rises both in the oil-film between the ring and the wall and in the space behind the ring. Since the space behind the ring is large compared to that in front of it, and the leakage path into the former space is small, an appreciable time is required for the space in the back of the groove to accumulate the additional gases required for a considerable rise in pressure. On the other hand, the pressure transmission through the thin surface oil-film is practically instantaneous. Therefore, there is a momentary tendency to collapse the ring at

the beginning of every power-stroke. If this differential pressure is great enough to overcome the ring tension, the ring collapses and forces the ends together sharply. Moreover, as the pressure falls, the expansion of the gas behind the ring combines with the ring tension to force the ring violently outward against the cylinder again. The sound results from either or both of these impacts.

According to this theory any method for filling the empty groove-space tends to counteract the trouble, as also does an increase in ring tension. Coasting with the ignition cut off fills the space partially with oil.

We have known of many cases being cured by the insertion of copper filling-strips. The cutting of grooves in the upper edge of the ring fills the space rapidly with gas, thus reducing the pressure-lag; this practice is, of course, not advisable.

This phenomenon of ring click was reproduced on an experimental one-cylinder unit, running the piston against compression only, no explosion, and was cured by

(1) Fitting the piston more neatly to the cylinder

(2) Relieving the top ring to allow pressure to get behind the ring. This was accomplished also by installing rings of thinner face in the top groove, but keeping the clearance in the two lower grooves as small as possible, as would be commercial practice in any service-station

The click was overcome in some instances also by installing rings of greater tension. The clicking of rings was noticed in both step-joint and angle-joint rings, and was overcome in all instances by pinning the rings in the grooves so that the joints did not line-up. It was noticed that clicking was most pronounced when the joints of the rings were approximately in line.

A number of years ago, when this clicking or slapping was brought to our attention, after considerable effort we arrived at a conclusion that we have been unable to disprove.

We have two types of ring installation that will cause this difficulty. One case is where the ring is properly fitted in the groove, but not so well fitted in the cylinder. If the face of the ring is off of the cylinder for a portion of its circumference, the gas pressure reaches the face of the ring and, being more or less checked by the lower rings and the skirt of the piston, causes a contraction of the ring in the groove. If the grooves are filed across the top side of the ring, the pressure reaching the back of the ring seems to offset the pressure on the face of the ring and the clicking stops without any further correction on the face of the ring.

A second case is an installation in which the rings fit perfectly against the cylinder wall but are very tight in the groove; so tight that considerable pressure is required to move them in the groove. We must expect that, while the ring is moving rapidly up and down in the cylinder, there will be a slight movement at least radially in the groove, because the piston clearance and cylinder conditions are never close enough to have the ring remain stationary in the groove. If, then, the ring moves slightly out or in and is pinched tight sideways in the groove, pressure can very easily reach a portion of the face of the ring because the ring is not allowed to "set" out actively in contact with the cylinder. The pressure acts the same as in the first case, driving the ring in; and at the end of the stroke the ring springs back to normal. We have always been able to correct this trouble by removing sufficient metal from the side of the ring to allow it to be free in the groove.

We have tried a number of times, unsuccessfully, to find a connection between the quantity of oil used and this condition. Of course, any projection from the shoulder in the cylinder would cause a noise if the rings were permitted to strike it. But the noise is entirely different from the click or slap experienced in the cases mentioned above.

There is a great tendency to make the fit between the ring and the ring-groove closer. It is very easy to make piston-rings to close limits in good surfaces, but it is a different problem to make piston-ring grooves up to the same standard. We believe that the proper width of ring, together with the proper side-surface on the ring and the groove, will be as effective as a very tightly fitted ring. We think that 0.00075 in. is the limit of tightness in ring-fits in the average commercial job.

SEASONING CAST-IRON PISTONS

Question:—We have been told by some high authorities on the subject that a heat-treatment of piston castings in the rough tends to make them easier to machine and to relieve them of strains so as to keep them from warping after they are finished and put into the job. The method recommended is to let the castings lie in a furnace at 1450 deg. fahr. for about 12 hr. Then, we have been told that seasoning of the rough castings is most beneficial. Still another suggestion is to heat the semi-finished piston to a blue color. Other authorities on the subject have denied both the need and the desirability of any such treatment. Can you give us additional information on this question?

Answer:—In reply to this query we have permission to quote, anonymously, the following opinions of a number of engineers who are specially qualified by experience to discuss this matter.

For practical production work, it has been our practice to heat-treat or anneal the pistons after the roughing cut at as low a temperature as would do, that is, not over 750 deg. fahr. After the annealing, we ground or took a light finishing-cut before grinding. I do not think that this method is as good as aging before the finishing process but it is more practical as a production method.

We have had intermittently considerable experience with the treatment of gray iron for pistons and feel that the highest-grade product is made from castings that have been subjected to a preliminary tumbling process in the foundry cleaning-room and then subjected, for about six weeks, to a yard-seasoning where the castings are exposed to the elements. Such castings are not as easy to machine as those which have been heat-treated from the standpoint of annealing. When time will not permit yard-seasoning, we resort to heat-treatment. We find that the castings cut much more easily, but the metal becomes somewhat lifeless from the standpoint of resilience, and a slight bump or shock of the finished article will cause a permanent set, which is not the case with castings that have been yard-seasoned only. It has been our experience that change of shape in the engine is prevented by sufficient yard-seasoning, as well as by heat-treatment. After all, either method may be used to normalize the iron. We prefer the seasoning process.

It is my opinion that pistons for internal-combustion engines should be heat-treated. In the first place, light-weight pistons must be made of very strong iron which almost approaches steel castings. Inasmuch as the combined carbon depends upon the rate of cooling, and the graphitic carbon being very much less than in ordinary cast iron, piston castings, especially the thin sections, are apt to chill or harden in the mold, making them difficult to machine. For that reason alone, piston castings should be annealed. Furthermore, even with

the most thorough annealing, some internal strains may remain; therefore, for a first-class job, pistons should have an additional treatment between the roughing and the finish-machining processes, in order that they may keep a permanent form after the last finish-grinding.

Our practice is to anneal the pistons prior to machining.

We believe that cylinders warp more than pistons. We therefore do not heat-treat our pistons and cylinders.

The main reason for heat-treating is to relieve the internal strains. Our present method for doing this is as follows: the pistons are first rough-turned, packed in boxes or containers which hold about 12 pieces each, and then placed in a furnace that has been brought to a temperature of 1450 to 1500 deg. fahr. and the heat turned off. The procedure of preheating the furnace we found necessary to eliminate the scale that would otherwise form on the exterior due to flame contact. The pistons are allowed to remain in the furnace from 2 to 2½ hr., after which they are removed and cooled in the air. After this treatment, the pistons present a bluish tint in the way of discoloration. Our old practice on larger sizes was to place the pistons in the furnace as received from the foundry. The heat was then applied and the contents heated to a cherry red, when the flame was turned off and the pistons allowed to cool in the furnace. This was more of an annealing process but we found in some instances that the castings were too soft to conform to our standard.

The United States Bureau of Standards informs us that it has recently started an investigation on a subject related to the heat-treatment of pistons for machining and permanence but that no data are available at the present time. A letter from the Bureau referred to the following five papers on the subject:

C. J. Wiltshire, Elimination of Strains in Castings, *Foundry*, Oct. 1, 1919, p. 684.

L. M. Sherwin, The Effects of Seasoning on Gray-Iron Castings, *Foundry*, October, 1917, p. 435.

J. F. Harper and R. S. MacPherran, The Annealing of Gray-Iron Castings, *The Iron Age*, Oct. 19, 1922, p. 1007.

J. E. Hurst, The Growth of Internal-Combustion Cylinders, *Engineering*, Aug. 4, 1916, p. 97; also The Heat Treatment of Cast Iron at Low Temperatures, *Engineering*, July 4, 1919, p. 1.

These contain the following information on this subject. Wiltshire recommends that

> The castings be placed in the oven, the doors closed, the heat turned on, and the temperature raised to 700 deg. fahr., which generally takes from 7 to 8 hr. This temperature is held for an additional 7 hr., when the heat is shut off and the oven allowed to cool down slowly for approximately 20 hr., with a resulting temperature of about 300 deg. fahr. The oven doors are then opened and the temperature is allowed to drop to approximately 150 deg. fahr., when the castings are in shape to be taken out. The entire operation consumes about 48 hr. The ovens are heated with oil and the amount of oil per ton of castings heated has averaged 9.6 gal. Each heat requires 284 gal. of oil. Approximately 29 tons of castings are treated each heat.

Sherwin is interested in finding a treatment of cast iron that will assure its holding its shape permanently after it has been formed into straight-edges, surface-plates and other castings of a similar nature. He finds that for this purpose some sort of seasoning of the castings is beneficial and recommends the second method given below as the most suitable. Among the methods of seasoning practiced by various manufacturers, Sherwin records the following:

(1) The castings remain in one place and position for an indefinite period, in some cases exposed to weather conditions, before being finish-machined

(2) The castings are rough-turned or planed, and then subjected to a heat of several hundred degrees, say as high as 400 deg. fahr., for a definite period of time

(3) The castings are heated from 150 to 300 deg. fahr. before having the scale removed

(4) The castings are heated and reheated several times at 400 deg. fahr.

Sherwin points out that, from what is known about the metallurgy of cast iron, any temperature below the critical point, 1250 deg. fahr., should be satisfactory for relieving strains, and he proves his contention experimentally by showing that test-bars, identical except for the heat-treatment, are indistinguishable as regards tensile-strength and Brinell-hardness and Shore-scleroscope numbers. The bars received the following treatment:

(1) Heated at 400 deg. fahr., for 24 hr.

(2) Heated at 1100 deg. fahr., for 24 hr.

(3) Heated to 1100 deg. fahr., three times, cooled down between each heating

(4) Untreated

Harper and MacPherran made a more extensive investigation of the point raised by Sherwin, namely, "What are the correct time and temperature for heat-treating cast iron to relieve machine and casting strains and to increase machinability?" Their results may be summarized thus:

(1) The rate of cooling has no effect on the physical properties of cast iron so long as the critical temperature is not exceeded

(2) To relieve machine and casting strains, a temperature of 1150 deg. fahr. for 1 hr. should not be exceeded. Continued heating at this temperature is followed by a loss of hardness and strength

(3) Annealing at 1050 deg. fahr. for reasonable periods does not tend to decrease materially the hardness or strength

(4) For increasing machinability, temperatures of from 1450 to 1550 deg. fahr. will be found satisfactory, but in this case the drop in hardness is accompanied by a decided loss of strength

The two papers by Hurst indicate that the situation is not as simple as the three papers just mentioned would lead one to believe. This discrepancy is due to the fact that Hurst discusses the subject from the standpoint of the permanence of the shape of the castings after they have been put into use under conditions where they are subjected to continued or intermittent heating. Under these circumstances, cast iron frequently undergoes a peculiar growth with a consequent increase in volume, a phenomenon that has been known for some time but that is far from being completely understood. Hurst's papers cannot be abstracted here but they are worthy of study, most profitably in connection with chapters 10 to 12 of W. H. Hatfield's book on Cast Iron in the Light of Recent Research, where will be found a readable account of what is known about the effect of temperature on articles made of cast iron.

Gear Grinding

By R. S. Drummond[1]

Detroit Section Paper *Illustrated with* Photographs

THE author discusses only gear-grinding work on gear-teeth subsequent to heat-treatment and pays particular attention to automobile transmission gears. He states that as yet very little is done in the grinding of gear-teeth that have not been heat-treated.

The salvaging of gears that have been rejected and the finish-grinding of gears that have grinding stock remaining upon the teeth are commented upon, together with remarks on the cost of grinding, the history of gear grinding, the different classes of work performed, gear-grinding machines in general, tooth-form and gear wear. It is stated that gear grinding is commercially a production operation having as its aim the placing of the correct tooth-shape and proper surface-finish on gear-teeth so that the gears can move accurately, noiselessly and without wear; and that the cost of finished acceptable transmissions is less than when the process of finish-grinding is used.

WE normally grind the teeth of gears after the heat-treatment. This paper will have particular reference to automobile transmission gears, which constitute a very large part of our work. Very few gears are made by grinding teeth that have not been heat-treated. We had experience last year with two lots of soft oil-pump gears that were sent to us by different manufacturers as being noisy. In both cases we returned the gears with the advice that they were cut very accurately. When they were received by us they could hardly be forced together on their true centers; they were soft and required only additional backlash to provide oil clearance.

Many instruments that have been designed to show tooth curvature are of great assistance in securing accurately cut soft gears, as they enable the operator to keep a careful check on the production of the machine that is more valuable than the current practice of rolling gears together on studs. Accurately cut gears will be greatly distorted by the later process of heat-treatment which distorts the teeth so that, unless they are ground, quiet, accurate movement is impossible.

The importance of grinding the bore and face of automobile gears has been well known for years, and great progress has been made in this work. It has been customary from time to time to finish-grind one part of the automobile and then another after heat-treating it. The grinding takes the place of the old method of finish-machining the parts before heat-treating them and then fitting the badly shaped parts together by touch or measurement. Gear teeth, so far, have not been given the same attention and poorly finished gear teeth and distorted tooth-shapes have been assumed by some manufacturers to be unavoidable. We bespeak for gear grinding your favorable consideration as being a logical development and an accurate process.

H. J. Eberhardt recently pointed out[2] the progress that has been made in the finishing of gear teeth. He showed that during the first period of their efforts the manufacturers used forms and cutters made in the tooth-form, and that many such machines listed in old catalogs had been abandoned; that in the second period generating machines were used to cut the teeth; and that in the third period the cutters and the gear teeth were ground after being hardened.

Salvaging Versus Finish-Grinding

There are two large volumes of gear-tooth-grinding business: first, the salvaging of gears that have been rejected as noisy or ill-shaped; and, secondly, the finish-grinding of gear teeth on which there is sufficient grinding stock left to allow accurate grinding.

The bulk of gear-tooth grinding, in the years gone by, was in the salvaging of gear parts that had been rejected in automobile transmissions. When manufacturers had gear trouble it was possible to take noisy gears that had already been cut to size, and to resurface them to an accurate tooth-form that would run quietly in a transmission. A large number of the gears furnished for salvaging were badly distorted by heat-treatment; a smaller number were originally cut to an inaccurate tooth-form. It is possible to grind the surface of such gear teeth so that the tooth-form shall be true and give quiet operation.

The grinding of salvage gears removes a certain small amount of stock from both sides of the tooth. This stock is from 0.003 to 0.006 in. in depth of cut and represents an average reduction in the chordal thickness of the tooth at the pitch circle of 0.008 in. This does not mean that 0.008 in. is removed from the entire surface of the tooth. This 0.008 in. represents the normal maximum increase in backlash in a given gear; such gears mated together are increased in backlash to a maximum of 0.016 in. Many gears salvaged in this manner require the removal of only 0.002 or 0.003 in., the backlash being 0.004 in. in a given gear, and 0.008 in. in a pair of such gears mated together. The backlash introduced into the gears when salvaged varies with the degree of inaccuracy in the product and not by the amount of stock necessary to be removed in the grinding operation.

A majority of mechanics and superintendents believe that the introduction of additional backlash will cause noise in the gears. We find that most of the noise usually attributed to additional backlash can be credited to the improper introduction of excessive backlash, as it is customary for manufacturers to secure backlash by pushing the cutters out of the true position, thus misplacing the tooth-form.

We have tested a large number of transmissions with ground gears that had backlash as high as 0.030 in. yet were quiet in operation, the only noise in the gears occurring when the car surged and the car speed exceeded the engine speed, the backlash accumulating into a single tap as the car surged. With proper backlash the oil-cushion between the teeth reduces the noise due to the surging action. Other than this single tap with each surge of the car there is no noise, no growl, no hum, no sing. When the car surges into second speed the backlash between the four gears accumulates and will cause

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[2] See *Mechanical Engineering*, August, 1921, p. 530.

the single tap already mentioned, but otherwise four such gears with a total backlash of 0.060 in. will run quietly under normal operation.

During the last year we have salvaged for one firm 40,000 gears that were finish-cut before heat-treatment, and 35,000 for another company. Such salvaging is usual in the building of automobile transmissions, and this class of work will continue to be a factor in the gear-grinding business just so long as the attempt is made to finish the teeth before heat-treating them.

The finish-grinding of gear teeth having grinding stock constitutes the largest volume of gear-tooth grinding. The gears are furnished with the teeth made to normal machine limits, not to gear limits. These limits are easily maintained by any method of gear-tooth cutting and the practice is the same as is customary on so many other standard parts of an automobile. It is usual for us to receive such gears rough-cut or hobbed, by a single cut, with a variation in the tooth thickness of from 0.006 to 0.010 in. over the required size of the finished tooth. The grinding stock, approximately 0.003 in., that is removed from each side of the tooth during the grinding operation, is usually sufficient to eliminate the distortion due to heat-treatment. The limits of 0.006 to 0.010 in. over the required tooth thickness allow cut-gear blanks to be produced rapidly by the most ordinary processes of gear-cutting.

The main pinion, or sleeve-gear, in many cars is designed so that the teeth on the gear mesh with the internal teeth of the second-speed sliding-gear, and it is desirable that these two parts fit together accurately. When grinding these pinions it is usual for us to fit them to their mating second-speed gear. On the main pinion we prefer to have grinding stock of approximately 0.008 to 0.012 in. over the finished thickness of the tooth in order that an accurate, tight fit between these parts can be made.

The change in gear-tooth grinding from the salvaging of mis-shaped teeth to the finish-grinding of new product with grinding stock is the natural result of increased knowledge of gear-tooth grinding. Most manufacturers who now use grinding as the finishing operation began by using it as a salvaging operation. They found that the process was successful, and having been led to investigate the finish-grinding of rough teeth, they found that the expense of the finish-grinding process was relatively small when compared with that of gears cut to size and distorted by heat-treatment.

Cost of Grinding

The cost of the finish-grinding of roughed gears has been proved to be less than that of the usual process of finish-cutting, heat-treating and salvaging. In making a comparison of costs, it is important that the overhead expense of finish-cutting should bear the burden of the rolling, mating, scrap loss, sizing, running in of gears, changing transmissions on account of noise, and all other expense items that are so prevalent in finished-gear work. This total expense should be applied against the finishing operation, when the cost of finishing is compared with that of ground gears as grinding the gears eliminates all these items. We take gears that have been rough-machined and heat-treated and finish-grind them to a true tooth-form with a scrap loss that normally is less than 1 per cent. We thus assume the burden of all the above features of gear production.

Many manufacturers have found that the total cost of a finished transmission, accepted and placed in a car, is less when the gears are finish-ground after the heat-treatment than when they are finish-cut before the heat-treatment. Automotive manufacturers who have handled similar operations have changed from the old method of selecting the product and fitting the mismated parts to the better method of finish-grinding the parts to accurate limits. It is now standard practice to finish-grind all the essential parts of the car after heat-treating them, as it has been found that this practice is more economical in the end than machining the parts before heat-treating them.

History of Gear Grinding

Attempts at gear grinding have been numerous. Records show that as early as 1874 a man molded a wheel to the approximate shape of a gear tooth and used it for cleaning the surfaces of cast gear-teeth. He found the cast gears rather rough when they came from the foundry, so he put a molded wheel between the teeth of the cast gear and removed the burrs and the projections. H. M. Leland of Detroit developed the Leland-Ferris bevel-gear grinding machine, in which the edge of a wheel was used against the gear tooth and the tooth curve was generated to an approximately true curve. This occurred about 1898. There have been many other attempts at gear grinding. To grind gears accurately is an art; it has been attempted by many, but has been accomplished by few.

Our types of machine, made according to the Ward design, are described in a subsequent paragraph. They are illustrated in Figs. 1 and 2. We have developed a large amount of special equipment for the handling of gear-tooth grinding that has not as yet been placed on the market. It has been our purpose to continue the development of this equipment until we can handle the gear-tooth grinding of all types of gear.

Gear-tooth-grinding jobs of many sorts come to us. The large gears used on electric locomotive drives are sent because the finish cut gears develop so much noise after the heat-treatment that it has been found necessary to grind them in order that they may operate accurately without noise and have longer life. The machining of manganese-steel gears containing 13 per cent of manganese is a difficult job and is feasible only with a grinding wheel. We have ground the teeth of such gears up to 20-in. face, ¾-in. pitch and 3 to 4-ft. diameter. Some of these are shown in Fig. 3. In some instances the tooth shapes were ground out of the solid blanks. Grinding from the blanks was thought desirable because the distortion of the cast gear-tooth of high-manganese steel is very large. Some of the manganese gears were too wide for our early types of machine, but we were able to mount the gears on an arbor, grind the faces of the teeth in one direction, then reverse the gear on the arbor, grind back again to the other grinding cut and, by careful and accurate alignment, make the grinding cuts meet. Airplane gears require accuracy and long life. A large number of tractor gears are salvaged after the heat-treatment. The distortion in such gears frequently causes more noise than a tractor engine with the muffler open. Many thousands of these gears were too noisy for open-air use on tractors. Plain bevel gears such as are used normally in rear axles have been ground by us in large quantities. These types give a fair idea of the variety of gear work that we handle commercially and indicate the wide range of the requirements for grinding gear teeth.

Types of Machine

Our machines are built in either the planer or the shaper type, the emery wheel taking the place of the

cutting tool. The shaper-type machine is shown in Fig. 2. The wheel is mounted so that its formed face passes through the gear-tooth space, grinding both sides of the tooth and the bottom at each cut. Gears are mounted on this machine either singly or in groups as conditions allow. Where a number of gears are mounted on an arbor they are brought into accurate alignment, then the wheel passes through the tooth spaces of the several

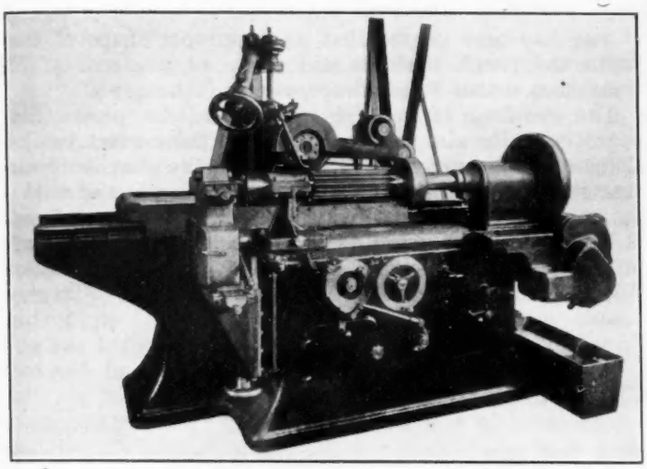


FIG. 1—THE PLANER TYPE OF GEAR-GRINDING MACHINE

gears. After this the arbor is indexed, the wheel again passes through the next tooth-space and the operation is repeated around the gear.

The shape of the wheel used in grinding is accurately formed by diamonds that scribe or cut the tooth-form on the face of the grinding wheel. Those who have tried to shape wheels for other purposes may find it hard to realize that we are able to perform this operation accurately and quickly. The operation of shaping the wheel has been well standardized and brought down to a production basis and occupies only a fraction of a minute. We grind 150 sets of gears per day for one company and 100 sets for another firm in continuous production. The operation of the machine is so accurate and simple that, having completed an arbor of say eight gears, the variation in the grinding on the different gears will not be sufficient to register on the testing apparatus.

TOOTH-FORM

Aside from the errors of distortion from heat-treatment, there is probably no error that has so great an influence on production as the variation of the tooth-form. We have known men to hide away certain cutters that they felt were producing gears accurately, to save them for emergency use. Recently a cut gear was sent to our company by such a man, who stated that he had been cutting gears successfully with the same cutter for 4 years and had saved it especially to cut more gears when needed. He said that his recent trials had not been successful, that the gears produced were very noisy. After making a laboratory examination of the gear, we found four different shapes of teeth on the gear that were far out of true. The gear-tooth forms were high and low. This defect was due largely to the heat-treatment, but the tooth-form on the gears indicated that the cutting was inaccurate, and that the cutter had been improperly set in position.

It is true that many gears are cut wrong when soft, but the percentage of finish-cut gears that pass through

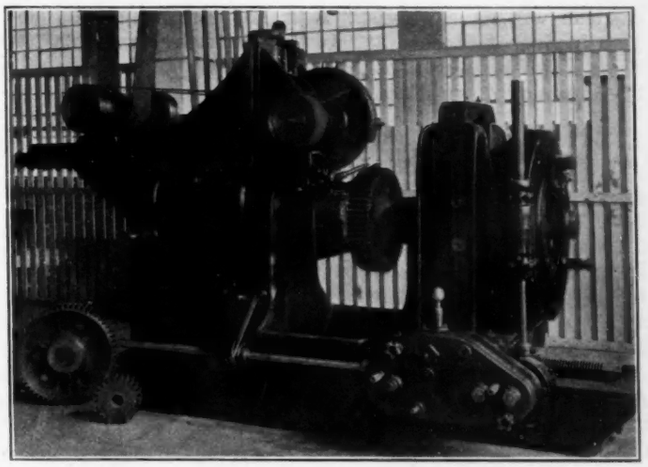


FIG. 2—A GEAR-GRINDING MACHINE THAT OPERATES ON THE SAME PRINCIPLE AS A SHAPING MACHINE

heat-treatment without any distortion is really very small. With the instruments available to-day, it is possible to determine variations in gear teeth after the heat-treatment. We recommend that tooth-form indicators be used. It is a good practice to put the finishing operation on the gear teeth after the heat-treatment; even if there is no other reason, surely the lessened interruption to pro-

FIG. 3—TWO TYPICAL EXAMPLES OF GROUND GEARS
The Upper View Shows Splined Shafts and a Stem Gear; in the Lower Power Motorboat Gears Having 44 Teeth and a Diametral Pitch of 3 Are Illustrated

duction will have weight. A manufacturer recently determined that it cost $19 to take out the transmission from a finished car and replace the noisy gears. He was then tearing down 50 cars per day.

Gear Wear

Much has been said recently concerning the wear of gear teeth. Special steel and methods of heat-treatment have been recommended in an effort to limit the amount of wear. All such efforts are worthy of consideration. Improper tooth-form causes abrupt acceleration and retardation that occur at least once for every tooth-contact, and is a large factor in tooth wear. Improperly shaped teeth accelerate the normal wear.

An article on the Investigation of Tooth Wear with Automobile Gear Steels, by E. R. Ross,[1] was submitted to the American Gear Manufacturers' Association at its October, 1921 meeting, in which much was said concerning the wear of gear teeth. This article shows where the wear starts and how it continues along the tooth as the gears run together. After the wear starts, it will cut into the surfaces and continue to grow along the teeth. The rate of wear is dependent largely on the material of which the gears are made, the method of heat-treating them and the distortion in the tooth-form that causes the wear.

With regard to other parts of the car, it has been proved, as it has been for gear teeth, that properly shaped surfaces, when finish-ground and running in oil, will last for a long time without an objectionable amount of wear; it has also been proved that any improper shape of the parts and rough surfaces will cause an acceleration in wear that makes for bad operation of the parts.

The grinding of gears is commercially a production operation. Its aim is the placing of the correct tooth-shape and the proper surface-finish on the gear-tooth so that the gears can move accurately, noiselessly and without wear. The cost of finished acceptable transmissions is less when finish-grinding is used. [The discussion of this paper is printed on p. 185.]

[1] See *Automotive Industries*, Nov. 3, 1921, p. 865.

THE BUSINESS OUTLOOK

A CAREFUL study of business statistics will convince one that there is not the regular periodicity about business cycles that is commonly assumed. There are many factors that may retard or hasten the movement; and in addition there are many modifying factors in such a relatively new industrial country as the United States. Daring and risk-taking have played such a large part in business success in this country, and business activity of a relatively high degree has been so much the normal condition, that it is difficult for many to believe that anything is normal except large profits and intense industrial activity. As industry and business become better organized, as control is more centralized and as more information about the market is available, such as probable demand, probable costs and probable supply, planning in advance becomes more possible.

Goods and services are ultimately always worth what the consumer will pay for them and not simply what the producer thinks they are worth or even what they have cost him to produce. Prices cannot for any long period of time remain below the cost of production. But for some time, costs of production may not be secured due to the fact that production costs fall out of their normal relation to the permanent basic value of the product. We passed through a period of feverish industrial activity, enormous speculation and very high prices, followed by a period of drastic liquidation.

There may be little new in the purely ethical world, but in Man's reaction on Nature; that is, in the technological world, in industry and the sciences, there is much that is new. Our whole industrial and financial organization and structure is different from that of the post-Napoleonic or of the post-Civil War periods. Business is better organized and systematized. More is known about the market. News is rapidly disseminated over the world. Capital flows readily from one nation to another.

Readjustments of various kinds must still take place before the effects of war-time conditions can be wholly eliminated from consideration. This is especially true of the maladjustment that still exists between various commodities and certain classes in the community. The tendency of prices, at present, is upward, but not uniformly so, with the result that, on the whole, a better equilibrium of the price level is gradually being obtained. While business will doubtless continue on the upward trend through the larger portion of 1923, there are too many obvious adjustments which must be made that will prevent the upward movement from being carried along to any undue heights. Since transportation facilities cannot be quickly expanded, they constitute a severe handicap to the fullest expansion of business. Conditions abroad are approaching the point where force of necessity will compel some fundamental readjustments.

Our strong financial position is one of the few favorable factors in the international financial situation. Strong as this position is, it should not be assumed that the apparent strength is of such proportions as to warrant anything but a conservative credit policy. Great burdens in the way of assisting in the flotation of long-term investment securities have been placed upon the commercial banking structure of this country in recent years. It is doubtful whether the securities now in the hands of banks could be liquidated in large volume as easily as some would lead us to believe.

Among the outstanding factors in the present situation are:

(1) The present tendency of business is upward, but further increases above the existing physical volume of trade are handicapped by the lack of adequate transportation facilities

(2) The upward movement of prices may well continue in the case of some classes of commodities, but there will probably be a marked resistance to too rapid and too great advances in the case of consumers' goods. One of the unfortunate effects of the transportation situation is that it may produce a temporary "place scarcity" of some commodities, with the result that some unhealthy price advances may occur

(3) Wages, like prices, will probably reach higher levels in some lines of business. This, coupled with higher raw-material costs, in the face of a resisting market, will probably tend to restrict industrial profits, even though business activity continues at a relatively high level

(4) While the Federal Government has been making some progress in reducing expenses, there is no sound basis for assuming that any material reduction in taxes can be expected in the near future. As a matter of fact, if some of the plans that are now under consideration are put into force, taxes may tend higher rather than lower.—W. F. Gephart, Vice-President, First National Bank of St. Louis

Passenger-Car Developments and Prophecies[1]

By F. E. Watts[2]

THE past year's progress has been in two apparently divergent directions; one toward better performance and the other toward cheaper production. In the first class of changes, the engine has received most attention. The fundamentals of crankshaft design are being evolved and the variety of multiple-bearing shafts, disc-cheek shafts, counterweighted shafts, and the like, together with the use of double flywheels and of dampeners, shows that finality has not been approached. Naturally, this work has drawn renewed attention to the desirability of light reciprocating parts. In many cases this has resulted in the adoption of aluminum-alloy pistons and, in some few cars, forged-duralumin connecting-rods are being used. This last is a most significant development. Price alone stands in the way of a considerable use of the new aluminum alloys. It is to be hoped that aluminum manufacturers will find means during the coming year to reduce their costs, so that they can get the quantity business so vital to their industry and to ours.

Only meager progress has been made toward the better utilization of fuel. A majority of European cars have adopted higher compression, and use heavy thick-headed aluminum pistons, for thermal reasons only; but in this Country, where smoothness is more important than fuel economy, the light-weight split-skirt piston with narrow rings, often four or more per piston, predominates.

Developments in combustion-chamber shapes and in manifolds have not resulted in much change commercially.

The use of doped fuels is not commercialized as yet. All these are subjects of that fundamental research which is itself one of the most important and gratifying features of the year's progress.

Air-cooling will come to the front as an issue in 1923. So will the so-called "steam-cooling" systems, if the patent situation clears.

Ignition, starting and lighting developments show only detail improvements in this Country; but the combined generator and magneto has had important development abroad. The coming year may see progress in American machines of this type.

Camshaft design has made considerable progress, chiefly in the direction of securing quiet valves with considerable clearance between the valve and the tappet. There is a marked tendency toward the adoption of chromium and silicon alloys for poppet valves. Both these improvements increase the mileage between overhaulings.

Much development work is being done on sleeve-valve engines, and also on fuel-injection systems.

Three aids to engine durability have begun to attract attention. They are aluminum-alloy piston-heads that reduce the carbonization of the crankcase oil; oil stills that remove unvaporized fuel from it; and air-cleaners that prevent road dust from being carried into the engine with the carbureted air. At present, it is impossible to foretell the value of any of these.

The plate clutch has been developed to a point where it is evident that it will replace all other types for moderate powers.

In change gears the outstanding features are an increased adoption of high-carbon alloy gear-steels in this Country, in contrast to the continued use of case-hardened steels abroad; the continued increase in the use of ground gear-teeth; improvements in gear cutters and gear teeth due to optical methods of testing; and the tendency in Europe to reduce the number of forward speeds from four to three, in spite of the high price of fuel.

Universal-joint makers are preparing to give us shafts that will run reasonably true and not wear too rapidly. This is being accomplished by the use of oil lubrication on the metal joints, centering devices on the fabric joints and tubing of better quality in both types.

Rear axles have not been greatly developed. Front axles remain about the same as a year ago except that, in Europe, the increasing adoption of four-wheel brakes has brought new problems. A number of American cars will be equipped with brakes on all wheels before the end of 1923. They increase the safe speed of operation, but add complications such as cost and unsprung weight.

Steel wheels, both disc and spoked, are being developed very rapidly. Large-section thin-walled tires, such as 32 x 6-in. and 34 x 7-in., are being made experimentally. They give promise of superior riding qualities.

Chassis-suspension improvements are matters of detail, except that fabric and rubber shackles and supports have made real progress.

Fabric engine supports have made their appearance, and probably more of these will be seen this year.

Chassis frames in general are heavier and stiffer; this is due partly to the increasing number of closed bodies.

Closed-Body Quantity-Production

The most outstanding development of the year, however, is the adaptation of the closed body to cheap quantity production. Starting with four and five-passenger two-door bodies, rapid production methods have spread to other types. Cheaper framing, the development of unit assembly and progressive final assembly, and the adoption of belt molding in place of the overlapping joint are a few of the items that have contributed to lower costs. Two new styles have been evolved, the business coupe and the business sedan. They open closed-car markets that have scarcely been scratched.

Further development of closed bodies is proceeding along the two lines of the all-wood-and-fabric job, and the all-metal enamelled-job with detachable upholstery.

With a demand for closed cars estimated at between 40 and 60 per cent, it becomes increasingly important to get them out quickly and cheaply. To this end quick paint and enamel processes are being developed. The

[1] Annual report of the Second Vice-President representing passenger-car engineering.

[2] M.S.A.E.—Chief engineer, Hupp Motor Car Corporation, Detroit.

progress being made in regard to body hardware is astonishing.

Bodies, tops and seats are lower, and radiators and hoods are higher than formerly on most recent designs.

The "cubic capacity" of the bodies is less, which aids in the cheapening process that is going on in all the important details of the car. This process will, next to closed-body changes, be the most important development of 1923. It is the result of price competition.

Only one important step has been made toward the light car of the future. I refer to the new four-cylinder Lancia; with a 122-in. wheelbase, a 50-hp. engine and a touring body, it weighs only 1650 lb. Apparently, its value as a guide-post to the industry is not yet realized.

JANUARY COUNCIL MEETINGS

THE 1922 Council held the last sessions of its administration on Jan. 8 and 9, at New York City, the following being present: President Bachman, First Vice-President Whitbeck, Vice-Presidents Young and Watts, Past-President Beecroft, W. R. Strickland, H. M. Crane, W. A. Brush, C. F. Scott, H. W. Alden, A. W. Scarratt, F. W. Gurney and E. A. Johnston.

The financial statement showed as of Dec. 31, 1922, a net balance of assets over liabilities of $125,909.84, this being $8,341.90 less than the corresponding figure on the same day of 1921. The income of the Society for the first 3 months of the current fiscal year amounted to $68,106.40, including receipts from the sales of annual-dinner tickets. The operating expense during the same period was $64,673.88.

Forty applications for individual membership and 17 for student enrollment were approved. The following transfers in grade of membership were made: From Associate to Foreign Member, H. H. Winburg; Junior to Member, Julius F. Melzer and John M. Wood; Associate to Member, C. B. Curtiss and Edward Wotton; Service Member to Member, Frederick Y. Dawson, H. S. McDewell, Frederick A. Truesdell, H. C. Wilson and G. E. A. Hallett.

The following subjects were assigned to the Standards Committee:

High-Chromium Steel—Iron and Steel Division
Molybdenum Steel—Iron and Steel Division

At the session of the Council held on Jan. 9 Chairman Johnston, of the Standards Committee, reported in detail the action taken by that committee on the same day with regard to the proposals of 17 of its Divisions as set forth elsewhere in this issue of THE JOURNAL. The proceedings of the Standards Committee were approved for submission to the Society in meeting assembled on Jan. 10, for consideration in the matter of referring the recommendations of the Divisions by letter-ballot to the voting members of the Society for final adoption.

ORGANIZATION SESSION OF 1923 COUNCIL

The organization session of the 1923 Council was attended by President Alden, First Vice-President Crane, Vice-Presidents Masury, Warner and Scarratt, Past-President Bachman and Councillors Swetland, Scaife, Scott and Chryst.

President Alden announced the personnel of the 1923 Administrative Committees as follows:

CONSTITUTION COMMITTEE

C. B. Veal, *Chairman*

W. A. Brush — A. L. Riker

FINANCE COMMITTEE

H. M. Swetland, *Chairman*

Fred Glover — C. B. Whittelsey
E. S. Jordan — K. W. Zimmerschied

HOUSE COMMITTEE

C. F. Kettering, *Chairman*

A. J. Brosseau — Milton Tibbetts
E. A. Sperry — John Younger

MEETINGS COMMITTEE

M. P. Rumney, *Chairman*

O. C. Berry — T. Milton
T. J. Litle, Jr. — C. F. Scott
Thomas Midgley, Jr. — E. P. Warner

MEMBERSHIP COMMITTEE

L. R. Smith, *Chairman*

W. C. Keys — C. W. Stratford
H. J. Porter — A. M. Wolf

PUBLICATION COMMITTEE

E. P. Warner, *Chairman*

H. C. Dickinson — F. C. Mock
D. L. Gallup — O. E. Hunt

SECTIONS COMMITTEE

H. W. Slauson, *Chairman*

W. A. Brush — B. F. Kelly
H. R. Corse — O. A. Parker

President Alden announced that Past-President B. B. Bachman had accepted the chairmanship of the Highways Committee.

The following transfer in grade of membership was made: From Associate to Member, Mason P. Rumney.

Discussion was had as to the program of meetings outlined by the Meetings Committee for 1923.

The names of the members who will serve this year as Chairmen and Vice-Chairmen of the Standards Committee and its Divisions were reported. These are listed in this issue of THE JOURNAL, as well as those named by the Council for service on the various Divisions.

The next meeting of the Council was scheduled to be held in New York City on Feb. 26.

Vol. XII February, 1923 No. 2

Hobbing-Machine Operation

By JOHN EDGAR[1] DETROIT SECTION PAPER

THE author discusses briefly the major factors upon which the successful operation of hobbing machines depends. A distinction is made between difficulties that are presented by the hob itself and those due to the machine, suggestions for surmounting these difficulties being included. Emphasis is placed upon the fact that a hob is a precision tool, accurate within tenths of thousandths of an inch.

Methods of securing rigid rotation, the avoidance of run-outs, concentricity of rotation, accuracy of indexing, proper maintenance and other features are indicated. The condition of the finished tooth-surface is divided into two classes and commented upon, the influence of the holding devices used being mentioned. The author concludes that much of the dissatisfaction encountered in the hobbing process can be overcome if more careful set-ups of the hob and the work are made.

MANY engineers do not appreciate the full extent of usefulness of the hobbing process. A better understanding of its capabilities will do much to overcome their antipathy. Any suggestions that aid in better adapting its peculiarities to the needs of those who favor its use are always appreciated. The human element enters into its employment as in any other process of manufacture, and, to get the greatest benefit from its wonderfully simple operation, conditions of usage must be given proper attention.

As the quality of results is a varying factor in the discussion of any process, there being no well-established limits of toleration in general use in the somewhat mysterious generating processes, no great reliance can be placed upon the phrases "high quality," "accurate," "extreme accuracy" and "good finish," as comparing units. To obtain a comparative unit that can be used in a general discussion, one must be limited to some definite terms as is now generally the case in the processes of manufacture where the fine measuring instruments obtainable can be used and a fractional limit can be stated. The gear-cutting industry does not seem to have arrived at that state. Until some of the instruments now under development are perfected, there is bound to be much confusion and misunderstanding.

THE HOBBING PROCESS

The hobbing process, as well as other processes used in the production of gears for transmission and for timing-gear trains, will therefore continue to suffer as in the past. As a result, the process is made to shoulder much of the blame that should be placed elsewhere. There seems to be no better remedy for the difficulty in the meantime than the expensive process of meeting each case on its own merits. We hope that the final result of present development will make it possible to measure a gear in a conjugate sense with as definite results as we now measure a shaft for diameter and length.

In itself, the hobbing process presents few if any mechanical difficulties. Its mechanism is simple and direct in action; the one-way direction of movement eliminates many elements that we find to be trouble producers in other processes. Once properly adjusted, the mechanism will operate without further attention for a given length of time with good results; whereas, in alternate mechanisms, frequent and expensive adjustments and replacements are required if an equal degree of accuracy is desired.

The reason for any mechanism on machine tools is to work a tool in proper conjunction with the blank being operated upon. This is met in the hobbing machine when we get the hob working in proper relation to the gear blank. When we desire a quiet-running accurate gear, the hob must be a precision tool and, in making the ground hob to-day, the degree of accuracy required limits the toleration of error to tenths of thousandths of an inch in both lead and tooth outline.

Having obtained a hob of the precision type, we must follow in its use and in all the subsequent operations of sharpening and setting-up the same degree of care that is taken in its manufacture. Properly sharpened, this type of hob should not run out of true at the peripheral cutting edges more than a small fraction of 0.001 in., because any run-out there indicates a wabbly path of the generating edges. Provision is now made in the ground hubs at each end of the hob to check up the run-out of the hob as a whole when set up on the hobbing machine. These are supposed to show no movement of the indicator that is used for checking them.

HOBBING-MACHINE OPERATION

Assuming that the above conditions are met, we now come to other items that need attention to operate a hobbing machine successfully. The hob spindle should be run in closely fitting bearings so that no run-out is observable in its rotation, and all end-play must be eliminated. An indicator placed so as to check end-play should show no wabble of the needle when the spindle is rotating; in other words, the hob must be securely rotated in a fixed transverse plane and be concentric with the axis of rotation. The work spindle also must be held securely during its rotation in closely adjusted bearings, and the rotation of the work obviously should be concentric with the hole in the work spindle. The plane parallel with the sides of the gear should be perpendicular to the axis.

The accuracy of indexing is affected by the condition and the adjustment of the worm and the worm gear. The worm gear should be fastened securely on the spindle so that the pitch-circle will rotate concentrically with the axis of the spindle; also, it should have no side wabble. The worm should be adjusted until there is no appreciable end-play, and it should also run concentrically with its axis. The adjustment between the worm and the gear should be as close as it can be run without heating, which should be the case with little or no backlash in the mesh when run dry.

The intermeshing mechanism connecting the hob and the work spindles will not show any appreciable effect on the results if it is made to close commercial limits and kept in good condition. Bearings should not be

[1] Designing engineer, Barber-Colman Co., Rockford, Ill.

allowed to become too loose and gears too badly worn. Machines have been found in operation with the bearings worn so that the shaft would rattle in them and with gears worn lopsided, but they were still kept on production work with apparent satisfaction as to results. However, good results cannot be expected of any machine if it is not in first-class running-condition.

Operating Conditions

To just what extent the condition of the machine may show in the tooth bearing of the gears is a disputed question. It seems that we may divide the condition of the tooth surface into two classes; first, that which shows split and high or low bearings. Such bearings can safely be blamed upon the hob, because a regular wabbly condition of generating edges is the cause of the split bearing and also of the high or low and alternate bearing on the gear teeth. A wabbly lead or a run-out of form are the faults that should be remedied in the hob. These conditions could be obtained only in a machine, if the machine were at fault, in which the hob arbor is given a regular acceleration of angular velocity; but this is very unlikely to happen. If any variation in angular velocity does occur, the timing of the period would be altogether likely to be different for successive revolutions. This would lead to a choppy appearance of the tooth surface similar to that due to chatter, but not so regular and would tend to produce the appearance of a hand-scraped surface.

The second condition of tooth surface is that which shows a variation in the bearing along the face of the tooth parallel with the axis. This may show a bearing that alternates from one side of the tooth to the other with decided steps, or it may show what is termed a "cross-bearing," showing the bearing on alternate sides of the tooth at the extreme ends. This condition is due to the poor adjustment of both the hob and work spindles in loosely fitted bearings. Where this shows on the gears, the only remedy is to rescrape the bearings. Cross-bearings in spiral gears also are due to the use of change-gears that have not been properly computed.

When cutting helical gears, the amount of feed should be calculated to very close limits of from 6 to 10 decimal places, depending upon the width of the face. Spotty bearings in spiral gears may show a bad condition of the lead screw, due to either a drunken thread or to the thrust bearing being out-of-true. Where the lead screw is at fault, the fact can be determined by an examination of the gear, which will show a regular interruption of bearing across the face at intervals equal to the pitch of the lead screw measured parallel on the gear axis.

Holding devices often influence the finish of gear teeth and, in some cases where the layout is not carefully designed, they will produce bearings that cause the condition of the machine itself to be questioned. If the backing-up of the cut is not properly attended to, the strain set up by the cut will be gradually released when the hob is cutting through, causing a falling off of the bearing near the end of the teeth last operated on by the hob.

Cross-bearing is sometimes caused by a creeping of the work, due to its not being tightly held against the torsional thrust of the hob. This torsional thrust is not due so much to a wormlike thrust of the thread, but to the fact that the hob is set at an angle with the axis of the work so that a cross pressure is exerted. This condition is more often found where large work is being cut with merely the hubs of the gears as clamping surfaces. Creeping must be guarded against adequately in all spiral gear-cutting. Where possible, this can be effected by the use of a key.

When the work is clamped in gangs, the faces of the blanks must be parallel, within small limits; any error here will cause a run-out of the finished work. The actual error is difficult to measure after the work is clamped up unless the outside diameter is true with the hole, which is not often the case on production work. For accurate finishing-cuts, the policy of cutting but one gear at a time has much to commend it.

Everything that has been mentioned in this connection applies to the holding of silent-chain sprockets in the machine. To get the straight side of a sprocket tooth within the limits of error that the chain manufacturers require, necessitates the use of a hob of the high-precision type and extreme care must be used in setting it up. Hobbing splined shafts is a much more satisfactory proposition, because here we can work to definite measurable limits so that the confusion encountered in gear cutting is eliminated. Hobs for all finished work must be closely made as to form and carefully set up. Much of the dissatisfaction encountered in the hobbing process can be overcome if more careful set-ups of the hob and the work are made.

To those who use a hobbing machine daily, its operation becomes second nature. For that reason I have not mentioned various points that there may be some question about in the minds of many engineers. [The discussion of this paper is printed on p. 185.]

THE MOTOR TRUCK AND OUR RAILROADS

(*Concluded from p.* 154)

very brief. Barring a very small proportion, involving exceptional and unusual circumstances, all carload freight, even over very short distances, can be handled with far greater efficiency upon railroad lines than by truck. I think, therefore, the trucks should not seek to invade the carload field.

There is only one further thought that I wish to leave with you. The spirit in which all of our problems of coordination ought to be approached is one of live-and-let-live. For the men in both your occupation and mine, the primary purpose should be to guide the development of that relationship along sane and sensible lines, so that each form of transportation may be enabled to give to humanity the maximum service of which it is capable.

Vol. XII February, 1923 No. 2

How to Use Gear-Cutting Hobs

By S. O. Bjornberg[1]

Detroit Section Paper *Illustrated with* Photographs and Charts

SINCE a gear is a product of the cutting tool, the gear-cutting machine and the operator, it can be no more accurate than the combined accuracy of these fundamental factors. All gear manufacturers aim to eliminate split bearings, high and low bearings, flats and other inaccuracies in tooth contour, because a gear having teeth the contours of which comply with the geometrical laws underlying its construction is by far the most satisfactory.

Illustrations are presented to convey an understanding of the geometrical principles involved, together with other illustrations of testing instruments and comments thereon. The application of these instruments is termed quality control, which is discussed in some detail under the headings of hob control, machine control and gear control. The author states that these testing instruments enable a gear manufacturer to know what results he obtains with gears, hobs and machines, and thus assist in the securing of a uniform product.

GEARS that run quietly constitute one of the important requirements in a modern automobile. Since noisy gears are always found to be inaccurate, the problem of how to manufacture accurate gears is the paramount issue of today in the many plants that make gears for the automotive industry.

All gear manufacturers aim to eliminate split bearings, high and low bearings, flats and all other inaccuracies in the tooth contour, the idea being that a gear

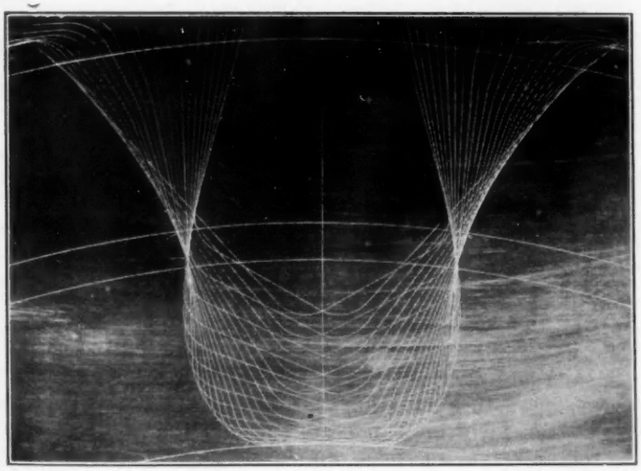


Fig. 1—Diagram Showing the Generation of a Gear Tooth by the Hobbing Process

having teeth the contours of which comply with the geometrical laws underlying its construction will make a better gear than one not having teeth so formed. A gear is a product of the cutting tool, the gear-cutting machine and the operator, and therefore it can be no more accurate than the combined accuracy of these three factors. If this fundamental statement is kept in mind by gear

[1] Consulting engineer, Illinois Tool Works, Chicago.

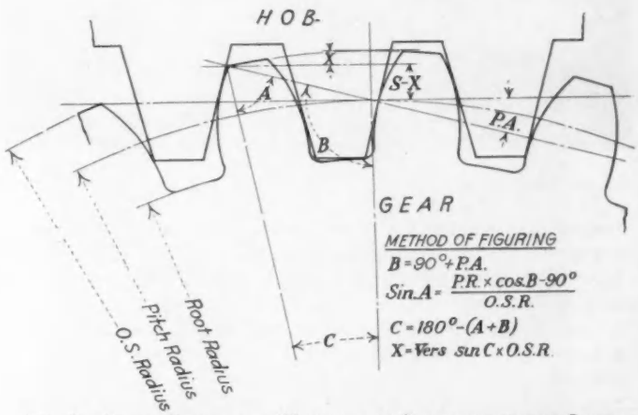


Fig. 2—Chart Showing a Method for Calculating the Last Point of Contact between a Gear Tooth and a Hob Tooth

makers, it will go a long way toward eliminating gear trouble, provided the system of gearing used is correct theoretically.

We have developed a number of inspection instruments to control the manufacturing process of gears, based on the fundamental laws of gearing. These instruments will help the manufacturer to know what results he is actually obtaining in regard to his gears. We have chosen to term the application of these instruments quality control, and have divided it into the three phases of hob control, machine control and gear control.

In considering the hob, it is necessary to understand a

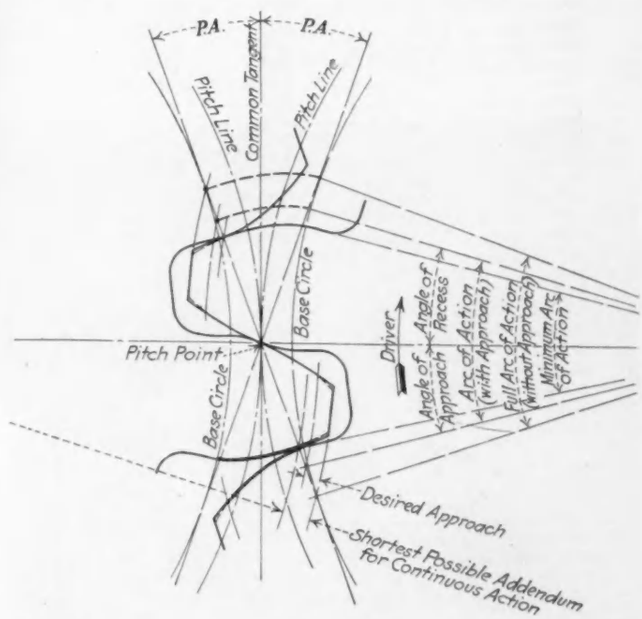


Fig. 3—Diagram for Determining the Arc of Contact between Any Two Mating Gears and the Length of Contact That the Involute Curve Has with Its Mating Gear Tooth

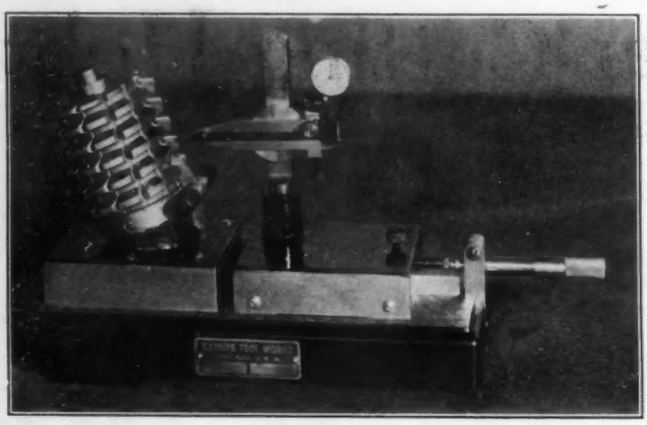


FIG. 4—A HOB IN PLACE ON THE CONTOUR-TESTING MACHINE

few of the geometrical conditions involved. Fig. 1 shows a gear tooth being generated by the hobbing process, and how the successive cuts of the hob teeth form the involute curve. Fig. 2 is a chart showing a method of calculating the last point of contact that a gear tooth has with a hob tooth. Fig. 3 shows the calculations necessary to determine the arc of contact that any two mating gears have, and also the length of contact that the involute curve has with its mating gear tooth.

In designing a hob it is necessary to know what these contacts are, because the present type of involute gearing is usually made with small approach curves at the addenda, and the hob has to be designed so that it will produce the required approach curves without breaking the arc of contact of the mating gears. After making these calculations, a hob must then be produced that will fulfill these geometrical laws correctly, and it must therefore have the correct contour on all of its cutting teeth. It must also have all its cutting teeth in the true helical path and all its cutting edges concentric. To check hobs for the three fundamental requirements of correct contour of teeth, proper location of contour on the path of the helix and uniform distance of contour from the axis of the hole, we have brought out instruments that will indicate how closely the finished hob approaches the ideal conditions.

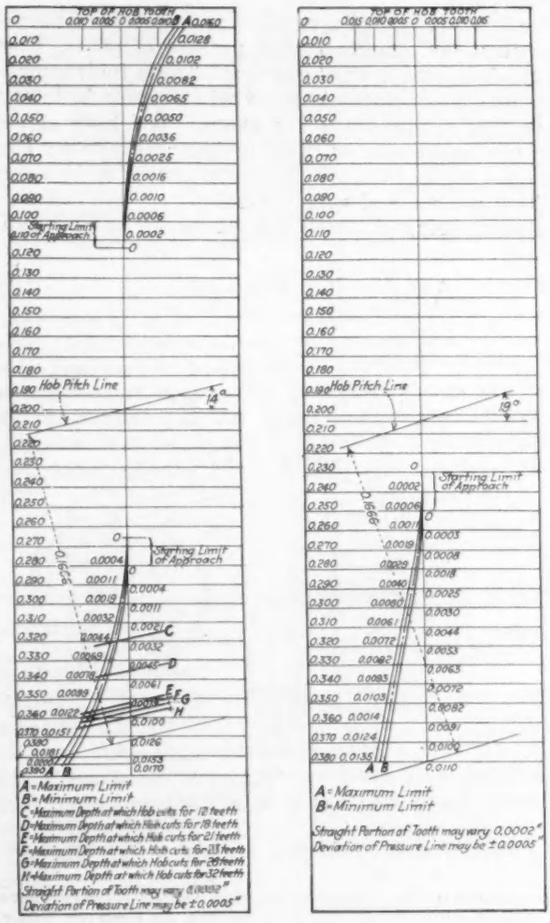

TOP OF HOB TOOTH
Hob Pitch Line
14°
19°
Starting Limit of Approach
A = Maximum Limit
B = Minimum Limit
C = Maximum Depth at which Hob cuts for 12 teeth
D = Maximum Depth at which Hob cuts for 18 teeth
E = Maximum Depth at which Hob cuts for 21 teeth
F = Maximum Depth at which Hob cuts for 23 teeth
G = Maximum Depth at which Hob cuts for 26 teeth
H = Maximum Depth at which Hob cuts for 32 teeth
Straight Portion of Tooth may vary 0.0002"
Deviation of Pressure Line may be ±0.0005"

FIG. 5—TYPICAL EXAMPLES OF FORM OR CONTOUR CHARTS

HOB CONTROL

Fig. 4 shows a hob on the contour-testing instrument. The indicator arrangement is constructed so that a movement of 0.001 in. of the contact point is registered as 0.005 in. on the dial indicator. Therefore a movement of 0.0010 in. on the dial indicator gives a movement of 0.0002 in. on the contact point. By this arrangement, it is possible actually to check the contour of the hob tooth in ten-thousandths of an inch. The instrument is very sensitive and, as the contact is a knife-edge, it will actually register such elevations and depressions as would be caused by rough grinding. The indicator slide is fed inward in increments of 0.010 in. at a time, and the readings are plotted on a chart. By drawing a curve through these plotted readings, a graphic record of the hob contour is obtained.

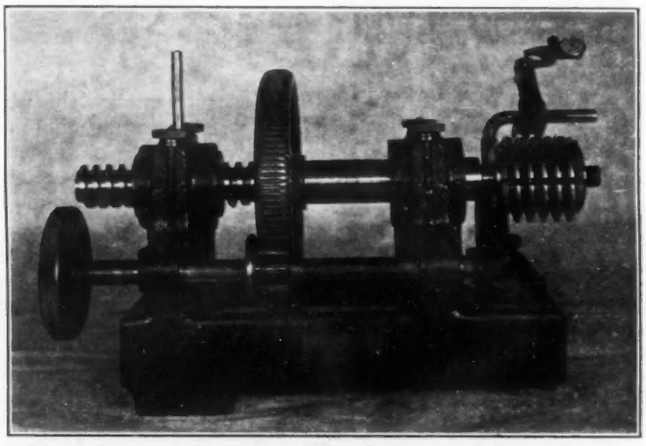


FIG. 6—A HOB ON THE LEAD-TESTING MACHINE

Fig. 5 shows several form or contour charts. On one of these charts the hob tooth has a curve at both the addenda and dedenda, the center line being the "master" form; the other two lines are tolerance lines, beyond which the form must not go. Should the hob be made to the extreme tolerance line at both addenda and dedenda, it will still cut gears that will roll without any interference, as these tolerance lines are placed so that they will not permit any interference. After it has been determined that a hob is correct in contour, it is then tested for lead.

Fig. 6 shows a hob on the lead-testing machine, which uses a master screw for each pitch of hob. The indicator arrangement on this machine also has a 5-to-1 ratio and will, therefore, register ten-thousandths of an inch. The contact point is brought against the cutting edge of the hob, and the indicator dial is set to zero. As the spindle is rotated, the hob is moved forward at the proper lead

and, if the hob has been made correctly, the indicator point should register zero on all cutting edges. If there is a weave in the helix due to grinding, or if the hole in the hob is large and, therefore, does not fit the arbor correctly, or if the gashes of the hob are not properly spaced, the indicator will register a great variation in the cutting edges as they pass by. Therefore, if the indicator point is considered as a gear tooth that is being cut, the necessity of having all of the cutting edges in a true helical path can be appreciated readily.

Fig. 7 shows two lead charts that have been plotted from actual hob readings. The points shown vary by ten-thousandths of an inch. The upper chart with the wavy lines shows a hob purchased in the open market. The lower chart shows a hob made to a specification, and this hob is extremely accurate. It is apparent that any deviation from the correct contour, spacing of the gashes and concentricity is detrimental. It is, therefore, necessary that the hob user at least provide himself with a means of knowing the concentricity in a hob, because a

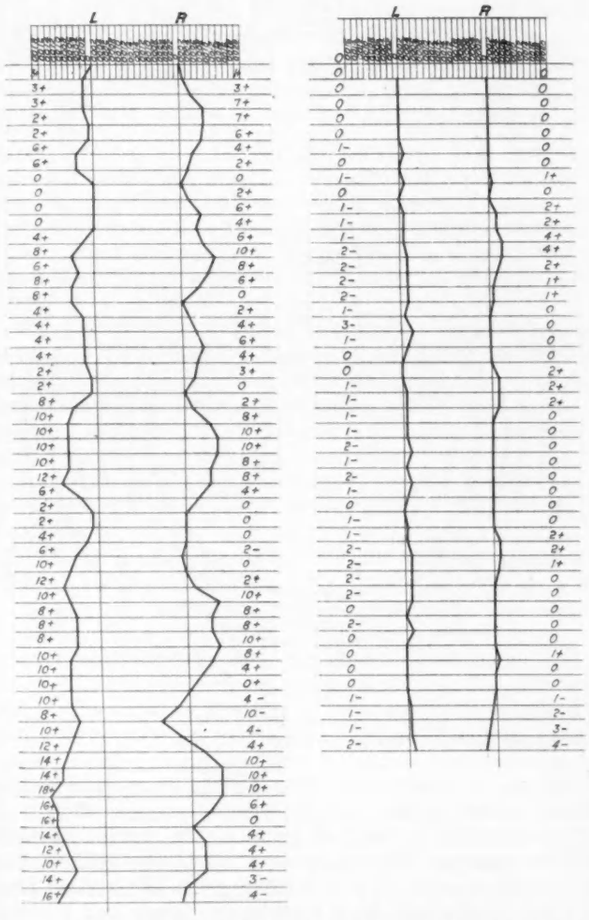


FIG. 7—TWO LEAD CHARTS PLOTTED FROM ACTUAL READINGS OBTAINED WITH THE MACHINE ILLUSTRATED IN FIG. 6

The Chart at the Left with the Wavy Lines Was Obtained from a Hob Purchased in the Open Market, While the Accuracy of a Hob Made to a Specification Is Evidenced by the Comparative Straightness of the Lines in the Chart at the Right

hob sharpener can spoil a good hob very easily by not sharpening it so that it is concentric.

Fig. 8 shows a hob on a fixture for testing concentricity and radial gashes. It is absolutely necessary that a hob be sharpened radially, because a hook or a drag on a hob tooth will raise and lower bearings on the gear teeth. It is necessary also that the gash be parallel with the axis

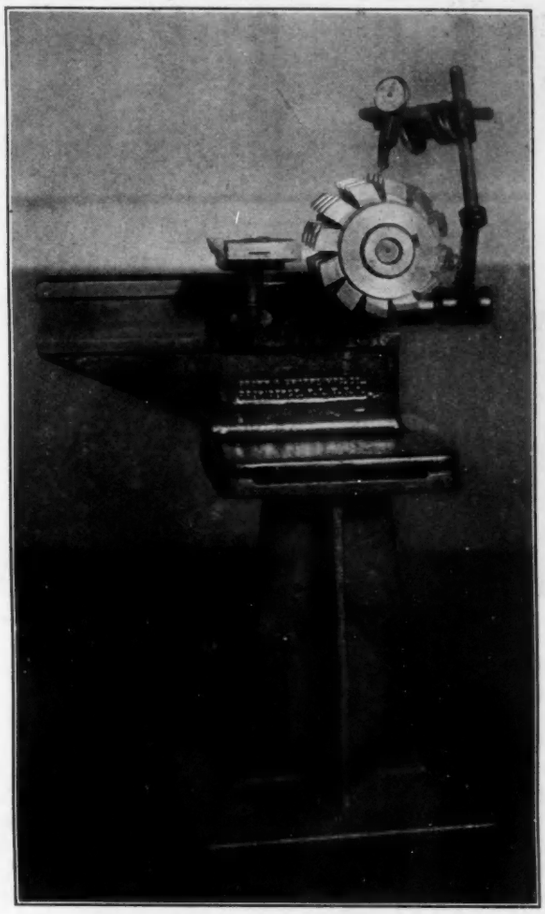


FIG. 8—A HOB IN PLACE ON A SPECIAL FIXTURE THAT TESTS CONCENTRICITY AND RADIAL GASHES

of the hob if a straight-gashed hob is used, or that it follow the true helical path if a spiral-gashed hob is used. The general practice is to use a hob in three or four positions and, if the gashes do not fall in their proper place, gear teeth of different contours will result from the different positions.

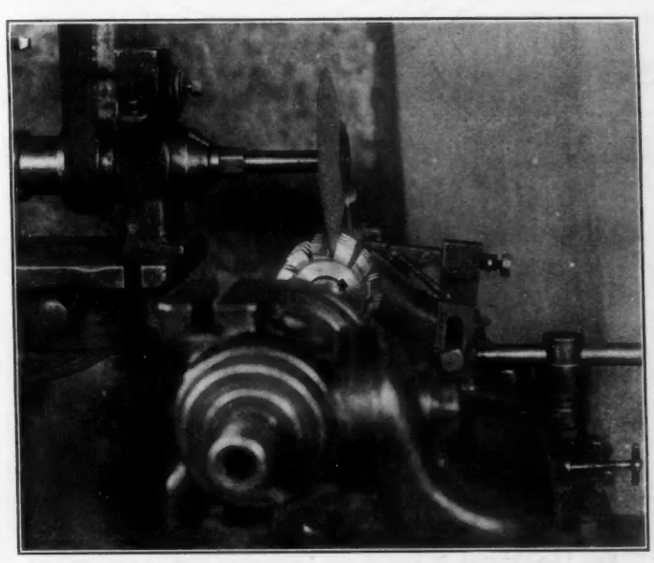


FIG. 9—A HOB BEING SHARPENED

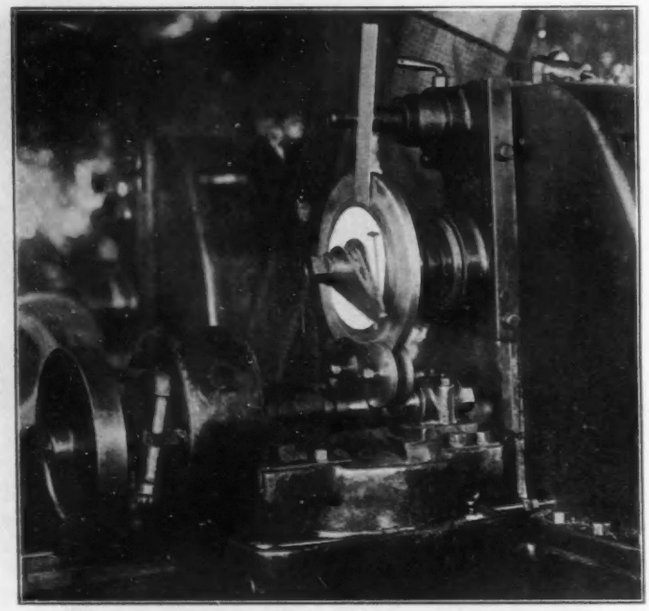


FIG. 10—TESTING FIXTURE THAT INDICATES THE UNIFORMITY OF THE MOTIONS OF THE HOB AND THE WORK ARBORS

Fig. 9 illustrates a hob on the sharpening machine and shows the position of the wheel and index finger. The cone side of the wheel is used in the sharpening of the straight-gashed hob. This method is strongly recommended because, if the cup side of the wheel is used on a straight-gashed hob, the wheel will grind more off the end teeth of the hob as it passes in and out, and will make a slightly warped surface on the hob teeth. By using these fixtures and methods, a hob user can check the hob he is buying and see that it comes within the limits of accuracy he has specified.

MACHINE CONTROL

A good hob does not always assure the production of good gears, because the second factor to be considered is the hobbing machine itself. One of the first requirements of a good hobbing-machine is that the velocities of the hob and the work arbors be uniform, so that tooth contours and spacings are regular. To test this uniform motion, we have designed the testing fixture which is shown mounted on a horizontal machine in Fig. 10. The idea of this fixture is to compare the velocity of the hob arbor with that of the work arbor. This is accomplished by having the work arbor carry an arm that rotates with it. A second arm is fastened to a disc, mounted loosely on the work arbor, the disc receiving its motion by frictional contact with intermediate rollers, the first roller being mounted on the hob arbor. Any variation of the velocity between the friction drive and the gear train of the machine will cause a displacement of the two arms, which is magnified by a system of levers and recorded by a stylus on a paper chart.

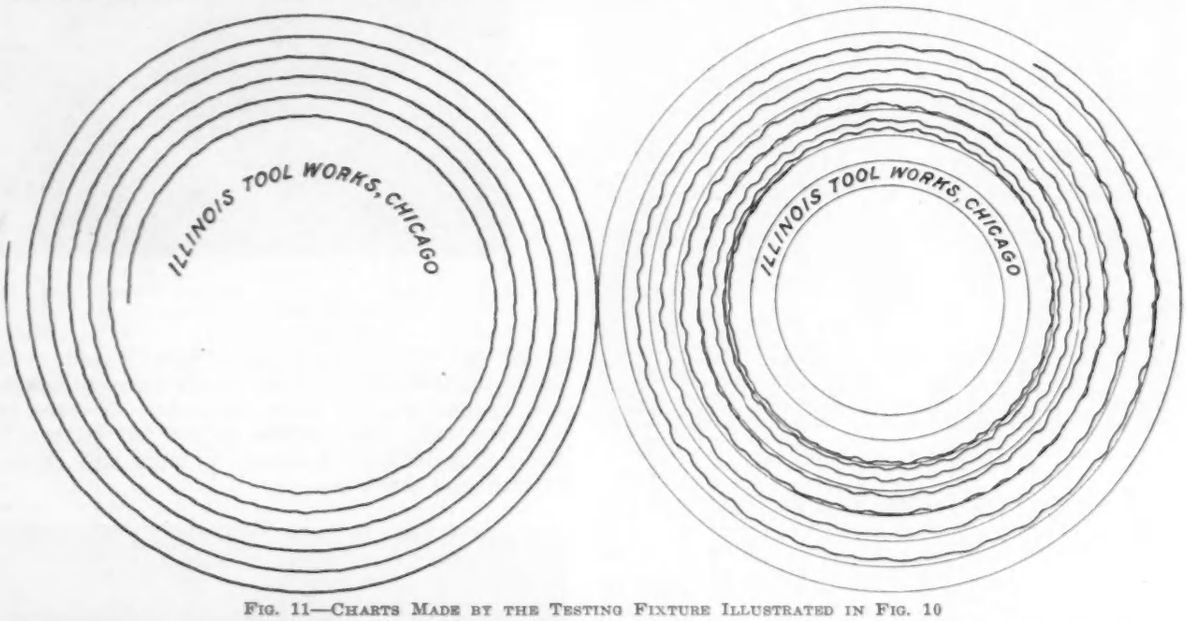


FIG. 11—CHARTS MADE BY THE TESTING FIXTURE ILLUSTRATED IN FIG. 10

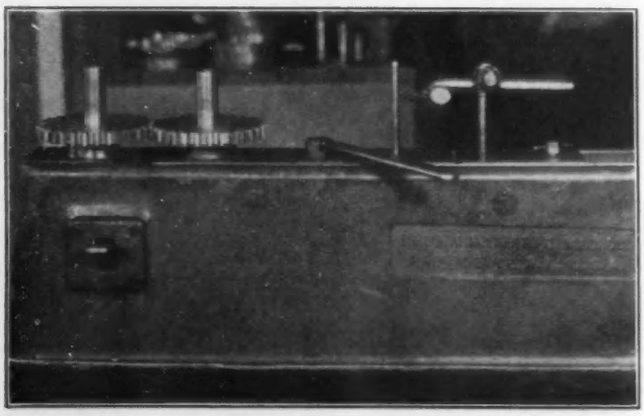


FIG. 12—VERNIER MACHINE FOR INDICATING THE CONCENTRICITY OF THE GEARS

Fig. 11 shows some charts made by this testing fixture. On the chart at the left the line is perfectly smooth; on the other chart there is a pronounced weave caused by some irregularity in the gear train of the hobbing machine. The machine that traced the wavy line cannot be expected to produce gears of great accuracy. With the instrument shown in Fig. 10, the gear manufacturer can easily discover why some of his gears show greater irregularity than others; also, he has the means available to check new machines he may desire to buy, and purchase only those that show true uniform motion.

In operating a hobbing machine it is necessary to give attention to the following points, which have an important bearing on the quality of the gears produced. The hob arbor must have all end-play eliminated and must run true. It happens often that the arbor runs true but, as soon as the hob is mounted, it is found to run out. This is caused by the threads on the arbor not being true with the axis of the arbor, or by the nut not being machined properly, which causes the arbor to spring when the nut is drawn up. These defects must be eliminated before good gears can be produced by the machine.

The springing of the work arbor, while not so serious, is also a factor to be considered. Gears made under this condition will run eccentrically on the test fixtures, which makes it difficult to check them properly. With the hobbing machine in good condition, a correct hob, properly machined work on hand, and the feed and index gears properly mounted, one would expect to obtain perfect gears; however, since the human element has not been eliminated in the operation of the machine, it is necessary to consider the personal equation.

Gear Control

To check the gears as they come from the hobbing machine, we use an ordinary vernier machine such as is shown in Fig. 12. This is the most common method of checking gears at present. It will indicate whether a gear is concentric and will show also how much jump there is between any two mating gear-teeth; however, it does not tell whether one of the gears is correct and the other incorrect, or whether they are both wrong, and how much.

Fig. 13 shows an involute testing-machine with a gear in place. This machine does not use bands, but the base circle of the gear rolls directly on the straight edge of the slide under spring pressure. The indicator will register the amount of deflection from the true involute path; therefore, it can be determined which of the two gears is incorrect and how much. If the involute curve is correct, the two gears should roll on the vernier machine without any jump per tooth.

Fig. 14 shows an angular-velocity testing-machine for gears. This machine consists of two pitch cylinders with a device for recording any variation in the angular velocity of the two gears. One of the gears is mounted solidly with the pitch-circle disc. The other gear is mounted so as to turn independently from its pitch-circle disc. The known motions of the two pitch-circle discs are used to test the unknown motion produced by the gear teeth when mating. If the involute curves are correct and the spacing of the teeth is uniform, a gear should go on the angular-velocity fixture and show no deviation in motion. It should also go on the vernier machine without showing any jump per tooth. A jump per tooth of several thousandths of an inch on the vernier machine will be somewhat more than that when translated into angular motion. When a gear having 60 teeth is running at 1000 r.p.m., there will be 60,000 accelerations and retardations per min. and this may be one of the reasons why gears make noise.

We believe that no gear manufacturer will go wrong if he provides himself with testing instruments that will enable him to know actually what results he is getting in his gears, hobs and machines, and that such instruments will help him to obtain a uniform product. This should be the aim of every gear manufacturer. It will enable him to reduce the gear business to at least a semi-scientific basis. In the past the gear manufacturer, not having any instruments for correctly checking them, has never known what his gear-tooth contours were.

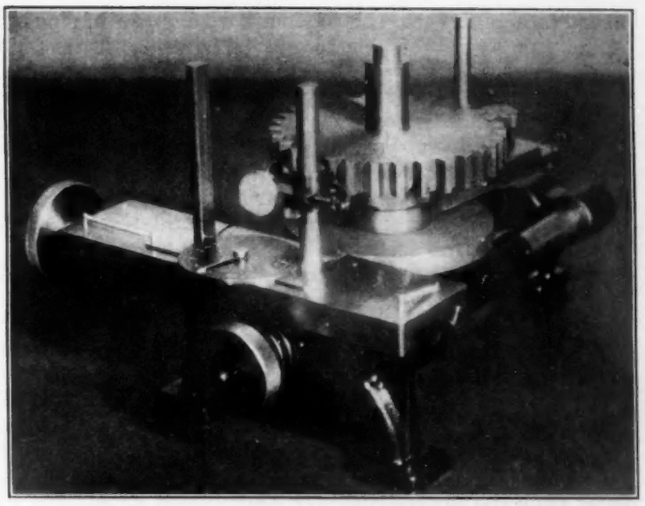


Fig. 13—Machine for Testing Involute Gears

THE DISCUSSION

Rex C. Darnell:—Is it possible to have the proper shape of bearing when grinding two teeth together; for instance, when lapping compounds are put between gears that are running, will the shape of the bearing be correct?

S. O. Bjornberg:—If a lapping compound were put between two gears that were originally inaccurate, they would tend to wear or remain inaccurate. Although the surfaces would lap rather smooth, there is no assurance that those surfaces would automatically become true involute curves, which is one of the geometrical laws that must be fulfilled in gearing. With two surfaces and a high line-bearing on them between the gear teeth, the high bearing might lap down somewhat but it will tend to lap a hollow in the mating gear-tooth; so, there is no assurance of getting correct contours by the lapping process.

A Member:—In my experiments along that line I did the lapping by going a little farther than trying to remove the high spots. I used a certain screw-thread comparator. In that way I have been able to rotate the gears together and, by doing so, I found that, where

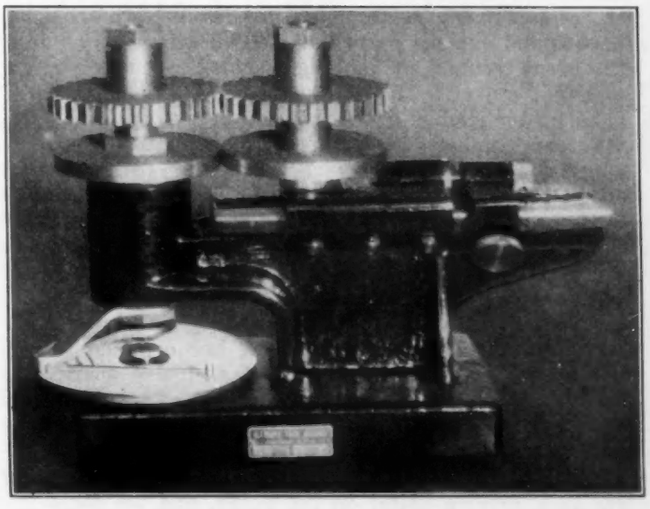


Fig. 14—An Angular-Velocity Testing-Machine for Gears

there is a high spot, the tendency with gears having an equal number of teeth is to wear a hollow right at that high spot.

A MEMBER:—In producing a ground gear, if the contour of the wheel is correct, you should get smooth action. Is it not found that just as good a result is had from a straight-tooth gear as from a helical gear, so far as quietness, wear and accuracy are concerned? What I mean is that, if a ground gear has straight teeth instead of helical or spiral teeth, we should be able to get results just as good as or better than we get with the helical gear; in other words, the ground tooth does away with the need of using helical gears.

R. S. DRUMMOND:—A simple design of gear-tooth form such as plain spur, or plain bevel, when ground to accurate tooth-form, should be as quiet as any shaped tooth can be. We have ground plain-bevel rear-axle gears and made them quiet; and we have ground plain spur gears for front-end gears and made them quiet, more quiet than the normal chain or spiral-bevel drives.

K. L. HERRMANN:—I wish there were some standard of quietness, or some measure of the amount of noise in gearing, so that the subject could be dealt with intelligently.

MR. DRUMMOND:—With reference to varying degrees of quietness, I, too, wish that we had a standard of noise. There is an element in a train of gears that introduces a sing of high pitch based entirely on the relative number of teeth, but this element can be distinguished from the hum of the metal contact between two gears that are running with insufficient oil-clearance, or are dry. It can be differentiated also from the growl that is introduced into even one pair of gears by incorrect tooth-form, and from the marbly rattle when one tooth does not carry over to the next with permanent contact, as frequently occurs with small numbers of teeth that are stubbed off.

A MEMBER:—In dressing the grinding wheel, do you use the same form to generate the gear-tooth that is used for the ordinary rack?

MR. DRUMMOND:—The gear-tooth form is made on a wheel from a similar gear-tooth form of larger size. We can reproduce whatever shape the enlarged template has.

W. F. ZIMMERMAN:—We have the same trouble with gears that everybody else has, particularly in trying to make a machine that will fulfill all the requirements that are now being shown up by the testing instruments that have been developed recently. We have used some of these instruments to test machines in our own shop, and have found various parts that needed attention. One of the great troubles of hobbing machines seems to be due to slight eccentricities in the gearing which are multiplied by the change-gears that are necessary for cutting different numbers of teeth. We have made diagrams which show that the inaccuracy is related to the number of teeth on a gear; that is, for each given number of teeth, there are a high and a low point on the diagrams. If there are no inaccuracies, we ought to get a continuous curve that is generally obtained by eliminating the change-gear trouble.

A considerable amount of trouble of this sort was encountered during the war when we had occasion to furnish a number of large machines for turbine gears, that run at 3600 r.p.m. These gears must run quietly and have a good bearing. Their faces were very wide; some were as wide as 72 in. Considerable trouble was experienced with "spotted bearings." This spotted bearing was in a reverse spiral on the gears, and we could not calculate it back into the gear train of the machine. Later, we found that most of this trouble was due to wrong adjustments, and that this reverse spiral was due to an improperly adjusted cutter spindle. Another trouble was due to an improper adjustment on the index worm, and still another was due to the end-thrust on the feed screw. The last mentioned cause can be measured on the gear very readily.

The wide turbine gears gave us considerable trouble in getting a good bearing across the entire face. Some of the manufacturers used laminated gears so as to avoid the uneven pressure and thereby provide a means for certain portions of the gear teeth to give under heavy leads and compensate for and equalize the pressure across the entire width of face. Extreme accuracy was required, and close attention was paid to the mounting of the gear so that it would be cut concentric with the axis of rotation.

After each blank was removed from the machine, the fixture was again trued and the blank set very carefully for concentricity. In the General Electric Co. shops, by careful attention as outlined, they were able to produce gears that needed lapping or running-in for about 1 day; whereas it required 1 week to lap-in some of the other gears.

As to lapping-in methods, gears generally have a very decided hollow on the pitch-line after being lapped, particularly those gears that have to be lapped for a week. Some of those wide gears were cut with multiple-thread and some with single-thread leads. It was found that the single-thread lead constituted the better proposition.

One of the great troubles in the gear machines has been the difficulty of obtaining concentricity of the gears produced, which is oftentimes confused with inaccurate spacing.

T. J. LITLE, JR.:—Does Mr. Drummond think that with careful grinding of the drive-gears in the front end of the engine he could cause the operation to be as silent as that of the silent chain?

MR. DRUMMOND:—It is possible to produce ground gears for the front-end drive that are commercially quiet. A large amount of noise introduced into the front-end gears actually is produced in other parts of the mechanism, such, for instance, as that due to an unbalanced shaft. Such noise cannot be ground out, but the noise that is due solely to gear operation can be satisfactorily ground out. Years ago front-end drive spur-gears were made without hardening and were quiet. This effect was secured by using extreme care and accuracy in the cutting.

To carry out the same idea, not only are front-end gears made quiet by grinding in the simple spur-gear design, but also ordinary plain bevel-gears in rear axles have been made to operate quietly by grinding out the distortion of the teeth. In former times we have seen plain bevel-gear axles that were quiet when made very accurately as to tooth-form.

Part of the interest in spiral bevel-gears is due to the need of eliminating noise. In different factories we find to-day that there is the same sort of noise and about the same amount of trouble in the later spiral designs that there was in the earlier ones, because of the bad shape of the teeth. Similarly, in the front-end drive, efforts have been made toward changing the material and the design of the teeth and introducing special-shaped teeth to eliminate the noise; but many factories using these peculiar methods are still troubled with the noise.

We should approach the problem of gear noise rather with a view to making the tooth-form as accurate as possible than to changing the design and the shape of the

teeth. It is better to use properly made spur gears than to use spiral gears, helical gears, gears made by the shaping method or chains.

If accurately cut gears are run together with a lapping compound, both gears will be ruined just as a plain shaft and a bearing would be ruined by putting emery on them.

MR. DARNELL:—With regard to how great the backlash should be, a statement was made that it might be as high as 0.03 in., but that seems to be entirely contrary to any experience that we have had. We made some calculations recently of what the reactions on the camshafts are and, taking the resultant of all forces involved, found certain peaks. We figured that we would be likely to get the most difficulty due to high backlash at a low speed and, particularly in truck engines when running with a wide-open throttle, some torsional vibration in the crankshaft is bound to occur. Further investigation proved that where the maximum reaction occurred on the camshaft, the greatest torsional vibration was shown on the crankshaft and this produced an extreme rattle. Consequently, we had to abandon the use of backlash that exceeded 0.005 in.

MR. HERRMANN:—I believe the backlash amounting to 0.030 in., referred to in our discussion, has been in connection with transmission and sliding gears.

MR. DRUMMOND:—The large amount of backlash referred to is in transmission gears, not in front-end gears. The backlash in front-end gears should be held within very close limits.

L. A. DANSE:—It is possible to heat-treat gears that are well cut so that they will mate pretty well afterward. We do not feel we are entirely beyond getting some help from the grinders, but we feel that with commercial accuracy in the cutting and ordinary care in the heat-treating, we will get commercial accuracy and a good match in the finished product and not have to resort to excessive lapping. We used to practise this lapping, and some of our gear lapping occasionally ran as high as 40 min. Our gear men now feel that if they have to run over 4 or 5 min. to clean up the teeth, it is better to scrap the gear. They think it is certain that inaccurate gear contour will result after that much lapping. In fact, our lapping time does not exceed 1.5 min.

A MEMBER:—There seems to be an impression on the part of many engineers and manufacturers that the silent-chain front-end drive is an expensive installation, and it has not been adopted for that reason. They forget that the front-end drive sometimes consists of three sprockets and chains, and that they are costly. The trouble that is experienced with gears in the average plant is not taken into consideration as compared with the cost of the permanent chain or the troubles they have with it. The noise in the front end is not always due to the gear design or to the front-end chain-design layout, but sometimes to the loading of the accessory shaft. The fact that some manufacturers have a very successful gear-drive as well as a chain-drive, while other manufacturers have trouble, although perhaps they are producing just as accurate work, is accounted for by their looking into the conditions of loading under which the gears operate. It often has been found that the difference between the loading conditions of two engines accounts for the difference in the amount of noise the engines make.

Another cause of noise in the gears as well as in the chain is crankshaft vibration. It has been proved very often that by eliminating vibration, particularly the torsional vibration, the chain noise is reduced and sometimes eliminated.

MR. HERRMANN:—There are two extremes of gear error; one causes a singing sound and the other causes a rattle. Has anyone been able to trace definitely the causes of the rattle and the singing and the causes of the intermediate steps? The rattle apparently occurs just a little too fast for the ear to detect the individual blows. Some ears can detect the individual blows at 15 vibrations per sec., while other ears are more sensitive and can detect the individual blows at 30 vibrations per sec. The higher-pitched tone or howl may correspond to tones ranging from 100 to 500 vibrations per sec. In a transmission the question is, just how much of the noise is due to gear-tooth form and how much to spacing error or other causes? I have heard indirectly that some very interesting experiments were made in this connection about 6 years ago.

A MEMBER:—I conducted some tests that indicate that the intensity of sound and the degree of pitch are in direct proportion to the number of teeth in contact. At the normal rotating speed, the indication is for a higher pitch when more teeth are in contact.

BENZENE AS ENGINE FUEL

MOTOR benzene is obtained as a coke-oven by-product. It conforms approximately to the following specifications: Distillation, first drop, 79.4 deg. cent. (174.9 deg. fahr.); 60 per cent, 100.0 deg. cent. (212 deg. fahr.); 90 per cent, 135 deg. cent. (275 deg. fahr.); residue, none. It must be neutral, containing no foreign substances except slight quantities of sulphur present as carbon bisulphide or thiophene to total approximately 0.25 per cent. Its specific gravity at 15.5 deg. cent. (60 deg. fahr.) is 0.878.

A distillation test of a high-grade motor gasoline compares with this as follows: First drop, 57 deg. cent. (134.6 deg. fahr.); 20 per cent, 100 deg. cent. (212 deg. fahr.); 60 per cent, 142 deg. cent. (287.6 deg. fahr.); 90 per cent, 197 deg. cent. (386.6 deg. fahr.); 93.5 per cent, or dry, 214 deg. cent. (417.2 deg. fahr.). The residue is 0.2 per cent and the specific gravity at 15.5 deg. cent. (60 deg. fahr.) is 0.732. Tests show that the motor benzene evaporates completely in about one-fifth the time required for the above sample of high-grade gasoline, because of the high end-point of the latter. The calorific value of benzene is 137,000 B.t.u. per gal., as compared with gasoline at 113,500 B.t.u. In an engine test 36 hp. was developed with the benzene as compared to 34.5 under the same conditions by gasoline. The total consumption was 0.109 lb. per b.hp.-hr. for benzene and compared to 0.122 lb. for gasoline, an increase of 10.7 per cent in efficiency in favor of the benzene. Moreover, the engine ran more smoothly on benzene, less carbon was deposited on the pistons and the cooling water was not so hot. Proper distillation of the benzene eliminates practically all the sulphur compounds, and so does away with corrosion troubles when this fuel is used.—W. O. Hinckley in *Chemical Abstracts.*

Tractor Industry in 1922[1]

By O. W. Young[2]

DURING the year 1922 the tractor industry has experienced a considerable revival of activity from the extreme depression of the previous year. While production has been very limited, in most cases, the liquidation of inventories so burdensome during last year has been accomplished largely and an optimistic attitude as to the future is becoming apparent throughout the industry. From available export figures, foreign trade appears to have been as low as any year since 1917, if not lower, due principally to low exchange-values.

Definite improvement has been evident during the last quarter of 1922 toward readjusting the balance of values of farm products with other commodities required on the farm. The farm credit-situation also has shown improvement. The effect of these changes already has been felt in increased interest in power farming and in reviving tractor sales in many lines. Prospects for continued improvement in this direction are very bright for the coming year.

Mechanical equipment on our farms is to a great extent depleted and worn out; it needs replacement and it is anticipated by some manufacturers that the demands for most types of farm equipment this year will exceed production, as estimated at present. It is felt, generally, that tractor prices will need to be advanced from the low and unprofitable levels prevailing during the past year.

Despite conditions, the power-farming idea has progressed this year in the esteem of the farmer. As evidence of this, it is significant that a considerable number of small two-plow tractors have been produced and sold during the year. While this perhaps is due mainly to the very low prices, nevertheless these units contribute toward popularizing power farming when put into the field. They usually represent initial purchases and, in the majority of cases, lead to a demand for larger and more efficient units, from the standpoint of labor cost in operation. While the general-utility and horse-replacement value of these small conventional units is limited, the low prices at which they were sold more than justified their purchase to expedite field work, handle peak loads and provide power for belt work.

During this period of restricted production, time has been put to good use in the development of new designs of various types and in important detail refinement. Much thought and experimental work have been directed toward the development of types providing for a wider utility range, especially for the handling of all operations pertaining to row crops. Considerable progress has been made toward a more general appreciation of the requirements of a general-purpose type. Also, new models of conventional type and refined construction have been developed and important improvements introduced in current models. Progress has been made in increased engine efficiency, due principally to improvements in fuel vaporization and in mechanical refinement.

TRACTOR DESIGN FUNDAMENTALS

Certain fundamentals of tractor design are becoming established more clearly. The general trend has been to somewhat higher ratios of power to tractor weight, and to decreased ratios of weight to drawbar performance. The increased power-weight ratios usually are obtained more in weight reduction than in power increase, the tendency being to limit the drawbar performance by weight and traction rather than by power; also to operate the engines at a more efficient power-range and in many cases with greater reserve. With decreased weight, it is becoming increasingly important to continue to improve the effectiveness of grouter and lug equipment, and possibly to develop other effective traction devices.

Important development work has been done on more efficient harvesting equipment of various types, and this will enhance power farming in some directions.

General progress in standardization this year can be said to be represented in the increased use of existing S.A.E. Standards in new designs, rather than in the formulating of new standards. The Society's exhibit at the National Tractor Show in February, 1922, did much to point out the value of S.A.E. Standards. It showed the surprising extent to which they are already applied in tractors, especially in engine details and fittings, materials, shaft splines, bearings and the like. A continuation of this educational feature in future tractor shows should be of value to stimulate greater interest in, and availing of, the Society's Standardization work.

Advance is being made in more logical and simplified standards for tractor belts, belt speeds and pulleys; ratings and test forms also are receiving thorough consideration and very likely will be ready for definite action during the coming year.

TWO PHASES OF TRACTOR ENGINEERING

Tractor engineering at this time can be said to present two major phases. One covers all the detail mechanical problems, from fuel utilization and engine and transmission design to the development of traction members, and includes the refinement and perfection of established conventional tractors. The other major phase has as its objects the extension of power application to all of the field operations of diversified farming, and centers in the development of a general-purpose type or types. Unquestionably, herein lies the greatest opportunity and most important problem before the tractor industry, the solution of which holds rich rewards.

The general performance specifications that an all-purpose tractor would be required to meet have been variously defined, but opinions agree on the broad essentials. The great possibilities of such a type, with reference to horse-replacement and labor-saving, and the immense potential market, certainly provide a fruitful field of endeavor for the engineering talent of the industry.

[1] Annual report of the Second Vice-President representing tractor engineering.

[2] M.S.A.E. Engineering manager, Hyatt Roller Bearing Co., Chicago.

Personnel of 1923 Standards Committee

THE designation of the Standards Committee personnel for this year has been completed, the Council having again taken action considerably earlier than in the years previous to 1922. The prompt formation of the 1923 Divisions will enable them to begin active work soon.

The Standards Committee for 1923 will be constituted of 27 Divisions. It is believed that these will form in the main a permanent group some one or more of which can be assigned practically any subject that the Council may approve for consideration in connection with standardization. Some of the Divisions will, of course, be more active than others at certain times. The total number of members of the committee will be about 15 per cent greater than that of last year and almost 35 per cent more than in 1921.

STANDARDS COMMITTEE

E. A. Johnston, *Chairman*
C. M. Manly, *Vice-Chairman*
G. W. Dunham, *Vice-Chairman*

AERONAUTIC DIVISION

H. M. Crane, *Chairman*	Consulting Engineer
G. J. Mead, *Vice-Chairman*	Wright Aeronautical Corporation
Porter H. Adams	National Aeronautic Association of U. S. A.
A. F. Arcier	Wittemann - Lewis Aircraft Co., Inc.
V. E. Clark	Dayton-Wright Co.
W. L. Gilmore	Curtiss Engineering Co.
L. M. Griffith	National Advisory Committee for Aeronautics
J. L. Harkness	L. W. F. Engineering Co.
E. T. Jones	Air Service
Lieut. B. G. Leighton	Navy Department
G. C. Loening	Loening Aeronautical Engineering Corporation
R. G. Page	Air Mail Service
Com. H. C. Richardson	Naval Aircraft Factory
W. T. Thomas	Consulting Engineer
R. H. Upson	Aircraft Development Corporation.
Edward Wallace	Glenn L. Martin Co.
L. M. Woolson	Packard Motor Car Co.

AGRICULTURAL POWER EQUIPMENT DIVISION

C. B. Rose, *Chairman*	Moline Plow Co.
A. W. Scarratt, *Vice-Chairman*	Minneapolis Steel & Machinery Co.
J. B. Bartholomew	Avery Co.
C. E. Frudden	Hart-Parr Co.
A. H. Gilbert	Rock Island Plow Co.
R. O Hendrickson	J. I. Case Plow Works Co.
Pliny E. Holt	Holt Mfg. Co.
John Mainland	Advance-Rumely Co.
M. B. Morgan	Timken-Detroit Axle Co.
J. F. Max Patitz	Allis-Chalmers Mfg. Co.
O. W. Sjogren	University of Nebraska
L. W. Witry	Waterloo Gasoline Engine Co.
G. A. Young	Purdue University
O. W. Young	Hyatt Roller Bearing Co.
O. B. Zimmerman	International Harvester Co.

AXLE AND WHEELS DIVISION

C. C. Carlton, *Chairman*	Motor Wheel Corporation
C. S. Dahlquist, *Vice-Chairman*	Eaton Axle Co.
R. S. Begg	Jordan Motor Car Co.
T. V. Buckwalter	Timken Roller Bearing Co.
R. J. Burrows	Clark Equipment Co. (Also representing Motor and Accessory Manufacturers' Association)
L. W. Close	Bock Bearing Co.
J. Coapman	Russel Motor Axle Co.
H. E. Derr	International Harvester Co.
G. W. Dunham	Savage Arms Corporation
F. W. Gurney	Gurney Ball Bearing Co.
F. P. Hall, Jr.	Salisbury Axle Co.
G. W. Harper	Columbia Axle Co.
George L. Lavery	West Steel Casting Co.
A. M. Laycock	Sheldon Axle & Spring Co.
H. V. Ludwick	Budd Wheel Corporation.
C. T. Myers	Consulting Engineer
A. L. Putnam	Detroit Pressed Steel Co.
O. J. Rohde	Wire Wheel Corporation of America
F. A. Shuler	Shuler Axle Co.
Frank Spring	Courier Motors Co.
H. Vanderbeek	Formerly with Timken-Detroit Axle Co.

BALL AND ROLLER BEARINGS DIVISION

F. W. Gurney *Chairman*	Gurney Ball Bearing Co.
T. V. Buckwalter, *Vice-Chairman*	Timken Roller Bearing Co.
J. T. R. Bell	Railway Roller Bearing Co.
G. R. Bott	Norma Co. of America
H. E. Brunner	S. K. F. Industries, Inc.
E. R. Carter, Jr.	Fafnir Bearing Co.
D. F. Chambers	Bearings Co. of America
L. W. Close	Bock Bearing Co.
L. A. Cummings	Standard Steel & Bearings, Inc.
G. W. Dunham	Savage Arms Corporation.
F. G. Hughes	New Departure Mfg. Co.
G. L. Miller	Gilliam Mfg. Co.
R. G. Schaffner	Bower Roller Bearing Co.
W. R. Strickland	Cadillac Motor Car Co.
R. E. Wells	Hyatt Roller Bearing Co.

ROLLER BEARING SUBDIVISION

F E. Moskovics, *Chairman*	Nordyke & Marmon Co., Inc.
R. S. Begg	Jordan Motor Car Co.
J. T. R. Bell	Railway Roller Bearing Co.
G. R. Bott	Norma Co. of America
T. V. Buckwalter	Timken Roller Bearing Co.
A. C. Bryan	Durston Gear Corporation
L. W. Close	Bock Bearing Co.
G. W. Dunham	Savage Arms Corporation
A. A. Gloetzner	Covert Gear Co., Inc.
M. C. Horine	International Motor Co.
A. M. Laycock	Sheldon Axle & Spring Co.
G. L. Miller	Gilliam Mfg. Co.
R. G. Schaffner	Bower Roller Bearing Co.
L. M. Stellman	H. H. Franklin Mfg. Co.
Andrew Van Halteren	Motor Wheel Corporation
R. E. Wells	Hyatt Roller Bearing Co.

CHAIN DIVISION

H. S. Pierce, *Chairman*	Link Belt Co.
W. J. Belcher, *Vice-Chairman*	Whitney Mfg. Co.
D. B. Baker	International Harvester Co.
W. F. Cole	Baldwin Chain & Mfg. Co.
E. S. Corcoran	Kelly-Springfield Motor Truck Co.
H. F. L. Funke	Herbert F. L. Funke Co., Inc.

M. C. Horine	International Motor Co.
J. C. Howe	American High Speed Chain Co.
F. L. Morse	Morse Chain Co.
W. A. Rockenfield	Baldwin Chain & Mfg. Co.
L. M. Wainwright	Diamond Chain & Mfg. Co.

ELECTRIC VEHICLE DIVISION

E. L. Clark, *Chairman*	Commercial Truck Co.
Karl Probst, *Vice-Chairman*	Milburn Wagon Co.
G. L. Bixby	Detroit Electric Car Co.
A. K. Brumbaugh	Autocar Co.
J. G. Carroll	Walker Vehicle Co.
Hugh M. Pierce	Ward Motor Vehicle Co.
F. E. Queeney	Lansden Co., Inc.
Charles R. Skinner, Jr.	New York Edison Co. (Also representing National Electric Light Association)

ELECTRICAL EQUIPMENT DIVISION

F. W. Andrew, *Chairman*	Eisemann Magneto Co.
T. L. Lee, *Vice-Chairman*	North East Electric Co.
C. R. Alling	Underwriters' Laboratories.
Azel Ames	Kerite Insulated Wire & Cable Co.
W. A. Chryst	Dayton Engineering Laboratories Co.
S. F. Evelyn	Continental Motors Corporation
C. F. Gilchrist	Electric Auto-Lite Corporation
W. S. Haggott	Packard Electric Co.
F. C. Kroeger	Remy Electric Co.
B. M. Leece	Leece-Neville Co.
A. D. T. Libby	Splitdorf Electrical Co. (Also representing Motor and Accessory Manufacturers' Association)
W. P. Loudon	Westinghouse Electric & Mfg. Co.
Charles Marcus	Bijur Motor Appliance Co.
Ernest Wooler	Cleveland Automobile Co.

ENGINE DIVISION

J. B. Fisher, *Chairman*	Waukesha Motor Co.
R. J. Broege, *Vice-Chairman*	Buda Co. (Also representing Motor and Accessory Manufacturers' Association)
P. J. Dasey	Midwest Engine Co.
S. F. Evelyn	Continental Motors Corporation.
Pliny E. Holt	Holt Mfg. Co.
A. F. Milbrath	Wisconsin Motor Mfg. Co.
Louis Schwitzer	Automotive Parts Co.
M. J. Steele	Packard Motor Car Co.
Joseph VanBlerck	Joseph VanBlerck Engine Corporation
W. C. Ware	Fay & Bowen Engine Co.

FRAMES DIVISION

William A. McKinley, *Chairman*	Detroit Pressed Steel Co.
C. C. Bowman, *Vice-Chairman*	Standard Motor Truck Co.
E. A. DeWaters	Buick Motor Co.
L. J. Fralick	Hydraulic Pressed Steel Co.
O. B. Harmon	Parish & Bingham Co.
Ernest Wooler	Cleveland Automobile Co.

IRON AND STEEL DIVISION

F. P. Gilligan, *Chairman*	Henry Souther Engineering Co.
W. C. Peterson, *Vice-Chairman*	Atlas Steel Corporation
R. M. Bird	Bethlehem Steel Co.
H. T. Chandler	Vanadium Corporation of America
A. L. Colby	Representing American Society for Testing Materials
B. F. Cortwright	Wisconsin Steel Co.
J. B. Dailey	General Motors Corporation
L. A. Danse	Cadillac Motor Car Co.
C. N. Dawe	Studebaker Corporation of America
B. H. DeLong	Carpenter Steel Co.
A. P. Eves	International Harvester Co.
H. L. Greene	Willys-Overland Co.
G. F. Harper	Allis-Chalmers Mfg. Co.
William H. Higgins	Advance-Rumely Co., Inc.
E. J. Janitzky	Illinois Steel Co.
J. B. Johnson	Air Service
F. C. Langenberg	Watertown Arsenal
F. E. McCleary	Dodge Bros.
C. S. Moody	Minneapolis Steel & Machinery Co.
J. H. Nelson	Wyman-Gordon Co.
G. L. Norris	Vanadium Corporation of America
W. H. Phillips	R. D. Nuttall Co. (Also representing American Gear Manufacturers Association)
S. P. Rockwell	Representing American Gear Manufacturers' Association
Mason P. Rumney	Detroit Steel Products Co.
C. F. W. Rys	Carnegie Steel Co.
R. B. Schenck	Buick Motor Co.
M. H. Schmid	United Alloy Steel Corporation
H. J. Stagg	Halcomb Steel Co.
J. M. Watson	Hupp Motor Car Corporation

ISOLATED ELECTRIC LIGHTING PLANT DIVISION

E. B. Newill, *Chairman*	Westinghouse Electric & Mfg. Co.
C. E. Reddig, *Vice-Chairman*	Western Electric Co.
F. C. Barton	General Electric Co.
L. F. Burger	International Harvester Co.
G. M. Gardner	Globe Electric Co.
Bryan T. Hawley	Holt Power Light Co.
L. S. Keilholtz	Delco-Light Co.
Don D. Myers	Electric Auto-Lite Corporation
P. F. Shivers	Webster Electric Co.
F. L. Tubbs	Alamo Farm Light Co.
H. L. Zabriskie	Representing Electric Power Club

LIGHTING DIVISION

W. A. McKay, *Chairman*	Westinghouse Lamp Co.
C. A. Michel, *Vice-Chairman*	Guide Motor Lamp Co.
A. K. Brumbaugh	Autocar Co.
J. T. Caldwell	General Electric Co.
G. P. Doll	Thomas Corcoran Lamp Co.
C. E. Godley	Edmunds & Jones Corporation
C. A. B. Halvorson, Jr.	General Electric Co.
J. H. Hunt	General Motors Corporation
A. R. Lewellen	Chevrolet Motor Co.
H. H. Magdsick	General Electric Co.
W. J. Outcalt	General Motors Corporation
L. C. Porter	Edison Lamp Works
E. S. Preston	Chicago Electric Mfg. Co.
C. D. Ryder	Corcoran-Victor Co.
A. J. Scaife	White Motor Co.
J. C. Stearns	Culver-Stearns Mfg. Co.
F. W. Todd	Accessories Mfg. Co.
Thomas I. Walker	General Electric Co.
E. E. Wood, Jr.	Miniature Incandescent Lamp Corporation
Ernest Wooler	Cleveland Automobile Co.

PERSONNEL OF 1923 STANDARDS COMMITTEE

LUBRICANTS DIVISION

H. C. Mougey, *Chairman*	General Motors Research Corporation
W. E. Jominy, *Vice-Chairman*	Studebaker Corporation of America
Sydney Bevin	Tidewater Oil Co.
P. J. Dasey	Midwest Engine Co.
A. P. Eves	International Harvester Co.
W. H. Herschel	Bureau of Standards
K. G. Mackenzie	Texas Co. (Also representing American Society for Testing Materials)
C. H. Osmund	Atlantic Refining Co.
W. E. Perdew	Union Petroleum Co.
W. D. Reese	Fifth Avenue Coach Co.
Herschell G. Smith	Gulf Refining Co.
J. W. Stack	Standard Oil Co.

MOTORBOAT DIVISION

Irwin Chase, *Chairman*	Elco Works
W. J. Deed	*Motorship*
A. E. Luders	Luders Marine Construction Co.
Q. B. Newman	Coast Guard Service
Leonard Ochtman, Jr.	Joseph VanBlerck Engine Corporation
P. A. Proal	Red Bank Yacht Works
W. A. Roos, Jr.	Consolidated Shipbuilding Corporation
L. H. Thomson	Belle Isle Boat & Engine Co.

MOTORCYCLE DIVISION

C. B. Franklin, *Chairman*	Hendee Mfg. Co.
A. W. Herrington, *Vice-Chairman*	Quartermaster Department
W. S. Harley	Harley-Davidson Motor Co.

NOMENCLATURE DIVISION

H. L. Pope, *Chairman*	Wright Aeronautical Corporation
W. P. Kennedy, *Vice-Chairman*	Kennedy Engineering Corporation
J. B. Bartholomew	Avery Co. (Also representing National Association of Farm Equipment Manufacturers)
W. F. Borgerd	International Harvester Co.
W. S. Bouton	Hendee Mfg. Co.
W. J. Brandon	Avery Co.
H. R. Cobleigh	National Automobile Chamber of Commerce
W. P. Culver	American Auto Parts Co. (Also representing Motor and Accessory Manufacturers' Association)
A. B. Cumner	Autocar Co.
L. S. Keilholtz	Delco-Light Co.
V. E. McMullen	Hercules Corporation
Leonard Ochtman, Jr.	Joseph VanBlerck Engine Corporation
W. T. Thomas	Thomas-Morse Aircraft Corporation
L. C. Voyles	Nordyke & Marmon Co.
L. M. Woolson	Packard Motor Car Co.

NON-FERROUS METALS DIVISION

Zay Jeffries, *Chairman*	Aluminum Co. of America
W. R. Webster, *Vice-Chairman*	Bridgeport Brass Co.
A. G. Carman	Franklin Die-Casting Corporation
D. L. Colwell	Stewart Mfg. Co.
G. K. Elliott	Lunkenheimer Co.
John R. Freeman, Jr.	Bureau of Standards
E. S. Fretz	Light Mfg. & Foundry Co.
Albert J. Hall	General Motors Corporation
H. C. Mougey	General Motors Research Corporation
W. B. Price	Scovill Mfg. Co.
G. C. Rauhauser	Denby Motor Truck Co.
Sam Tour	Doehler Die-Casting Co.
T. H. Wickenden	International Nickel Co.

PARTS AND FITTINGS DIVISION

W. C. Keys, *Chairman*	Gabriel Snubber Sales & Service Co.
Clarence Carson, *Vice-Chairman*	Dodge Brothers
C. R. Alling	Underwriters' Laboratories
H. B. Garman	Garman Mfg. Co.
H. S. Jandus	C. G. Spring Co.
W. J. Outcalt	General Motors Corporation
F. W. Slack	Peerless Motor Car Co.
C. W. Spicer	Spicer Mfg. Corporation
E. W. Weaver	Weaver & Kemble Co.
F. G. Whittington	Stewart-Warner Speedometer Co.

PASSENGER CAR DIVISION

R. S. Begg, *Chairman*	Jordan Motor Car Co.
L. A. Chaminade, *Vice-Chairman*	Studebaker Corporation of America
Ralph C. Chesnutt	Templar Motor Car Co.
G. B. Sayre	Saxon Motor Car Co.
L. M. Stellmann	H. H. Franklin Mfg. Co.
J. H. Tuttle	Westcott Motor Car Co.
W. G. Wall	National Motor Car & Vehicle Corporation.

PASSENGER-CAR BODY DIVISION

A. J. Neerken, *Chairman*	Hupp Motor Car Co.
G. J. Mercer, *Vice-Chairman*	Consulting Engineer (Also representing Automobile Body Builders' Association)
E. J. Bartlett	Baker R & L Co. (Also representing Automobile Body Builders' Association)
R. E. Brown	Fisher Body Co.
Kingston Forbes	Buick Motor Co.
E. J. Connelly	Wilson Body Co.
A. E. Garrels	Studebaker Corporation of America
G. E. Goddard	Dodge Bros.
E. W. Goodwin	Maxwell Motor Corporation
R. A. LaBarre	Anderson Electric Car Co.

RADIATOR DIVISION

J. D. Harris, *Chairman*	McCord Mfg. Co., Inc.
James A. White, *Vice-Chairman*	Harrison Radiator Co.
H. A. Higgins	Long Mfg. Co.
H. B. Knap	Packard Motor Car Co.
Charles Oppe	G. & O. Mfg. Co.
C. T. Perkins	Modine Mfg. Co.
G. H. Pettit	Atterbury Motor Car Co.
S. W. Rushmore	Rushmore Laboratory
H. M. Yeager	Fedders Mfg. Co.
Fred M. Young	Perfex Radiator Co.
John G. Zummach	Zummach Engineering Service

SCREW-THREADS DIVISION

E. H. Ehrman, *Chairman*	Chicago Screw Co.
O. B. Zimmerman, *Vice-Chairman*	International Harvester Co.
Mr. Bradford	International Harvester Co.
Earle Buckingham	Pratt & Whitney Co.
E. Burdsall	Russell, Burdsall & Ward Bolt & Nut Co.
Luther Burlingame	Brown & Sharpe Mfg. Co.

G. S. Case	Lamson & Sessions Co.
William R. Mitchell	National Acme Mfg. Co.
Alex Taub	General Motors Corporation

SPRINGS DIVISION

S. P. Hess, *Chairman*	Detroit Steel Products Co.
H. R. McMahon, *Vice-Chairman*	Standard Steel Spring Co.
R. S. Begg	Jordan Motor Car Co.
E. S. Corcoran	Kelly-Springfield Motor Truck Co.
Wayne E. Dunston	C. G. Spring Co.
H. E. Figgie	Standard Steel Spring Co.
W. M. Newkirk	William & Harvey Rowland, Inc.
Gustaf Peterson	Atlas Steel Corporation
E. V. Rippingille	Watson Stabilator Co.
F. A. Whitten	General Motors Truck Co.

STATIONARY-ENGINE DIVISION

L. F. Burger, *Chairman*	International Harvester Co.
C. B. Segner, *Vice-Chairman*	Domestic Engine & Pump Co.
H. G. Holmes	Novo Engine Co.
V. E. McMullen	Hercules Corporation
I. J. Nelson	Nelson Bros.
T. C. Menges	Associated Manufacturers Co.
O. A. Powell	Cushman Motor Works
L. W. Witry	Waterloo Gasoline Engine Co.

STORAGE-BATTERY DIVISION

I. M. Noble, *Chairman*	Consulting Engineer
W. E. Gossling, *Vice-Chairman*	Prest-O-Lite Corporation
G. L. Bixby	Detroit Electric Car Co.
A. K. Brumbaugh	Autocar Co.
R. N. Chamberlain	Gould Storage Battery Co.
E. L. Clark	Commercial Truck Co.
Bruce Ford	Electric Storage Battery Co.
S. C. Harris	New York Edison Co.
W. E. Holland	Philadelphia Storage Battery Co.
C. T. Klug	Willard Storage Battery Co.
R. C. Mitchell	Edison Storage Battery Co.
J. L. Rupp	Westinghouse Union Battery Co.
G. W. Vinal	Bureau of Standards

TRANSMISSION DIVISION

A. C. Bryan, *Chairman*	Dursten Gear Corporation
L. C. Fuller, *Vice-Chairman*	Fuller & Sons Mfg. Co.
A. W. Copland	Detroit Gear & Machine Co.
D. E. Gamble	Borg & Beck Co.
A. A. Gloetzner	Covert Gear Co., Inc.
Joseph Jandesek	Formerly with Olds Motor Works
W. C. Lipe	Brown-Lipe Gear Co.
Walter M. Petty	Service Motor Truck Co.
C. E. Swenson	Mechanics Machine Co.
S. O. White	Warner Gear Co.
E. E. Wemp	Long Mfg. Co.

TRUCK DIVISION

A. J. Scaife, *Chairman*	White Co.
J. R. Coleman, *Vice-Chairman*	Selden Truck Corporation
A. K. Brumbaugh	Autocar Co.
H. E. Derr	International Harvester Co.
A. W. Herrington	Quartermaster Department
M. C. Horine	International Motor Co.
E. A. Kingsbury	Sanford Motor Truck Co.
H. B. Knap	Packard Motor Car Co.
J. A. Kraus	Garford Motor Truck Co.
Walter M. Petty	Service Motor Truck Co.
F. A. Whitten	General Motors Truck Co.

TENSILE PROPERTIES OF LOW-CARBON STEEL

FOR some time past a study has been in progress in the metallurgical laboratories of the Bureau of Standards on the properties of various grades of boiler plate through the range of from 20 to 465 deg. cent. (68 to 869 deg. fahr.). This has been conducted to determine the effects of blue and cold work, variations in the rate of loading and elastic overstrain and the subsequent behavior of the overstrained steel with time. The results of this work have been published in Technologic Paper No. 219 which describes the special apparatus employed for making high-temperature tensile tests and the differences in behavior of the steel that were noted in the various temperature ranges.

It was found that the proportional limit of the several grades of plates does not decrease with the first rise in temperature but is either maintained at about room temperature value or increases before the final decrease occurs. The increased strength produced by rolling cold or at blue heat, 300 deg. cent. (572 deg. fahr.), is maintained throughout a considerable temperature range, but these effects may be removed by suitable annealing. A high proportional limit exists while tempering cold-rolled plate at 300 deg. cent. (572 deg. fahr.) or after cooling to room temperature, an effect that can be used to advantage in the production of cold-finished products, such as thin-wall seamless steel tubes where bluing after the final cold-pass will produce a high elastic ratio.

Some effects of tensional elastic overstrain are also described in detail. Among the tests made are those showing that the proportional limit can be made to approximate the tensile-strength by overstraining successively at blue heat with gradually increasing loads. Differences in the behavior of overstrained steel upon etching are observed depending upon whether the overload is applied above 465 deg. cent. (869 deg. fahr.) or below blue heat, 300 deg. cent. (572 deg. fahr.). Likewise, the effect of a decrease in the rate of loading is different in these two temperature ranges, though little variation in tensile properties was observed when tests were performed 30 times as fast as would ordinarily be the case.

The Development of a Modern Service-System

By Don T. Hastings[1]

Chicago Service Meeting Paper *Illustrated with* Charts

THE author states that the word "service" has been and still is the most abused word in the automobile language and enumerates some of the causes of poor service. Good service is then considered as constituting a sales asset. The new attitude toward service is described and the progress of the building-up of a combined flat-rate and piece-work system is outlined.

The flat-rate and the piece-work features are analyzed, inclusive of the methods applied to each and comments upon the results obtained. Records form an all-important part, and these are kept on special forms that are illustrated; the method of their utilization is given in detail. The duties of the different members of the service personnel are specified, and it is shown how the different factors are made to combine and produce service that satisfies the car-owner.

THE word "service" has been the most abused word in the automobile language and, unfortunately, it still is in that position in a great many localities. If one mentions "service" to the average motor-car owner, he immediately visualizes a gloomy picture in which the high points are overcharges, poor work, discourtesy and delays, with a wonderful background of dirt. This picture has been the natural result of conditions which were allowed to exist for years by practically all motor-car dealers. Of course, all of them were not guilty on all the above counts, but some serious criticism was justified of each establishment. The result is that this composite picture was formed in the mind of the public.

Causes of Poor Service

The unsatisfactory service that has been given in the past can be traced to several causes. Many distributors, who were salesmen primarily, have looked on service as a necessary evil; consequently, they have paid little or no attention to it. It has been left to some mechanic to try to get by in fixing-up cars with as little expense to the dealer as possible and no regard whatever for the owner. Another prolific cause of poor service has been ignorance of the product on the part of the dealer, and of its requirements in the way of maintenance. Sheer laziness or inertia has caused these dealers to avoid spending the time and energy required to learn how to take care of cars, and such dealers have no conception of the possibilities of service as a sales asset. Another type of dealer who has helped to bring service into ill-repute is the man whose motto is, "get the money." This type has overcharged owners for work, and has insisted upon payment for it regardless of the justice of the charge or the owner's rights.

The builders of cars themselves have been responsible in a great many cases for the high-price evil, because of the exorbitant figures that they set up as the prices of repair parts. The dealer, of course, could do nothing but accept these figures, although he has followed the builder's example, in many cases, and added a high percentage to the factory price of parts in the guise of a charge for handling, freight, express, and the like. Producers also have been responsible for much of the poor service rendered, because they have not insisted that their distributors and dealers give the proper consideration and study to the service problem. So long as a sales volume was maintained, they have been short-sighted and left it to the individual dealer to decide what he should do with his service. Even among those manufacturers who talk service in a more or less feeble way, there has been a decided lack of the proper supervision and assistance that the average dealer must have if he is to succeed in giving good service without a prohibitive outlay.

Good Service as a Sales Asset

Most manufacturers and dealers have failed to realize that first-class service is one of the best aids to the sales department that it is possible to secure. The best advertising is conceded to be the word-of-mouth advertising that a satisfied owner does among his friends and acquaintances. No matter how well satisfied a man is with the car he has purchased, while it is new, he will not remain a booster unless he is able to get satisfactory treatment when in need of adjustments or repairs to his car. The dealer cannot expect orders from the friends of an owner whose standard line of talk is to the effect that his car is fine but that the service rendered by the dealer is poor.

Owners are buying cars more and more on the basis of good service. The average owner would be satisfied to own any one of four or five cars that are in the same price-class, and he is almost certain to inquire about the service given on the various cars before he signs an order. The dealer who has once instituted good service in his establishment is impressed almost daily by the remarks of prospects to the effect that they were rather inclined to buy some competitor's car until some neighbor boosted the dealer's service strongly enough to persuade them to buy one of his cars.

The New Attitude Toward Service

About 5 years ago, a few of the leading dealers in various parts of the Country began to realize that their service departments had not been conducted on the same high plane as had their sales departments. The result was that these few dealers studied the service problem and started to develop this end of their business. Each one, acting independently of the others, consciously or unconsciously adopted the Golden Rule as the goal toward which to strive in their service work. Each one put himself in the place of the individual owner, with the result that they took steps to make their establishments known as having the following service ideals:

[1] M.S.A.E.—Vice-President in charge of service, Williams & Hastings, Inc., Detroit.

(1) A square deal
(2) Courtesy
(3) Cleanliness
(4) Guaranteed work
(5) Reasonable prices
(6) Promptness of delivery
(7) Promises kept when made
(8) An adequate stock of parts

Many of the factories have realized in recent years that unreasonably high parts-prices were proving a handicap in the sale of cars. The result is that many of them now have such a price-list that the total price of all the parts or assemblies required to form a complete car equals or is less than the price of a complete new car.

Among the steps that have been taken looking toward the accomplishment of the ideals mentioned, perhaps the most important is the establishment of flat-rate or guaranteed charges for labor covering the various operations required in the repair of cars. Some of these flat-rate systems have been developed by individual dealers, and others have been prepared by the factories and transmitted to their dealers. It is much more satisfactory to the owner to be told, before the work is started on his car, exactly what the labor charge will be for the various operations required, than it is for him to come in when the work is completed, and find the bill far larger than he had anticipated. If the owner considers that any flat-rate charge is greater than it should be, he has the opportunity of cancelling his order for the particular work in question before it is started. Consequently, this system avoids the unpleasant arguments that occur all too frequently under the old method of charges for labor. One of the leaders in this work was Percy E. Chamberlain of Denver, whose messages on Flat-Rate and the Lady in White have been heard by hundreds of service managers in the last few years.

A bit of history now appears necessary to make clear what follows. In 1919, Mr. Williams and I arranged to secure the distributor's franchise for the Hupmobile for the lower Peninsula of Michigan, with headquarters in Detroit. Mr. Williams had had some 15 years of selling experience in the motor-car business, and I had been for about 12 years connected with the engineering departments of various motor-car companies. The quarters that we were able to secure were such that it was necessary for us to separate the sales and the service departments. The natural result was that Mr. Williams concentrated his attention on the selling end and I fairly lived with the service division. The word "lived" is used advisedly, because for the next 3 years practically all of my time, not only the days and the evenings, but Sundays and holidays as well, was spent in supervising and developing the service work. The building that we secured early in 1920, when the demand for space was far in excess of the supply, was rather small and extremely dirty; it was very poorly lighted and had been used as a storage garage. The floors were covered from ½ to 1 in. thick with grease and dirt, and the inside of the building was black with soot. As we were starting in with a service policy that covered most of the points listed above, our first big job was to clean house. More than a week was spent in removing the accumulated dirt from the floors alone. The inside of the building was sprayed with white paint, and adequate lights and wall outlets for electric-drill and extension-light connections were installed. Sectional wooden bins for handling parts were constructed and painted, and a preliminary supply of parts was installed. The bins were labeled with the part numbers, and a perpetual-inventory stock-record installed. At the end of a month we had a clean, well-lighted shop and parts department, with the skeleton of an organization, and were prepared to give service.

Our next big problem was to develop an organization through which to give owners courteous, prompt and intelligent service. For several months we went through the grief of trying out various men in the several positions. Finally we found suitable men and got them well started along the lines that we considered necessary in the way of educational development. Practically all of the men thus selected are still with our organization, and they have been given the first opportunities to move into more responsible positions as the organization developed. In connection with the educational program for these men, we sent our shop-foreman and our leading service-salesman to attend a course in shop management at the Young Men's Christian Association school, and paid one-half of the cost of the course.

The Flat-Rate System

Our early analysis of the service problem had convinced us that, ultimately, we would install a flat-rate system of charges for the customer, and that we would also install a piece-work system in the shop. We decided further that our flat-rate charges to the customer should, in the great majority of cases, cover labor only, as any system that attempted to include the cost of parts, lubricants, and the like, as well as labor, could be only an estimate system, instead of a definite statement of costs. The advantages of this flat-rate and piece-work system were summarized briefly as follows:

Advantages for the Car-Owner

(1) He is advised in advance regarding the cost of the job, so far as the labor is concerned
(2) The cost of the work to him is reduced
(3) He gets his car sooner, because it reduces the length of time required to do the work
(4) It eliminates any misunderstandings as to the charge, because this is arranged in advance

Advantages for the Dealer

(5) The cost of performing the work is reduced
(6) The tendency is to make the mechanic more careful; for, if his work is judged unsatisfactory by the foreman and the inspector, he must do the work over at his own expense
(7) More floor-space is created, because the work is performed faster
(8) The number of workmen in the shop is lessened
(9) More jobs are put through the shop in a given time
(10) Disputes over customers' bills are eliminated
(11) It eliminates incompetent workmen
(12) Loafing is done away with
(13) New cars are prepared for delivery in less time, and at a standardized rate

Advantages for the Mechanic

(14) His hourly rate while working is increased
(15) It increases his total monthly earnings
(16) His straight-time work is speeded up, so that he can get back on the contract
(17) The mechanic's dislike for certain jobs is eliminated
(18) It creates in him an inventive genius, and he designs tools to help him accomplish the work in a shorter time

We realized that to install such a system on a logical basis required, fundamentally, a knowledge of the vari-

ous operations required in handling repair work, and also of the average time required for each one of these operations. An analysis was made of the repair operations, and they were divided into 25 groups, each group consisting of a number of operations on a particular unit in the car or covering a certain class of work. The total number of operations listed, including those covering the installation of the more commonly sold accessories, was about 400. As soon as this list was prepared, two lines of work developed; the systematic recording of time and a method of making the operations specific.

The Time-Keeping System

It was necessary that the service-salesman write the instructions for each repair-job in such a way as to segregate the operations required in accordance with this new list. It was necessary also that the time-keeping system be arranged so that accurate time was obtained on each operation. The service-salesmen were perfectly willing to cooperate, but it took some time to educate them to analyze the customers' requirements in terms of our operation list. A consistent study of the list and of various work orders on my part and by the service-salesmen eventually resulted in having the orders written properly. The big stumbling-block was to get the time properly reported by the mechanics. Again a process of education and elimination was resorted to, the trouble-makers in the shop left the organization and the records began to come through in fair shape. A time clock was installed to assist in this work, and it seemed to fit the requirements. The outfit has proved to be very satisfactory, since it has an advantage in that electrically controlled time-stamps, working from the master clock, can be installed at any point in the building.

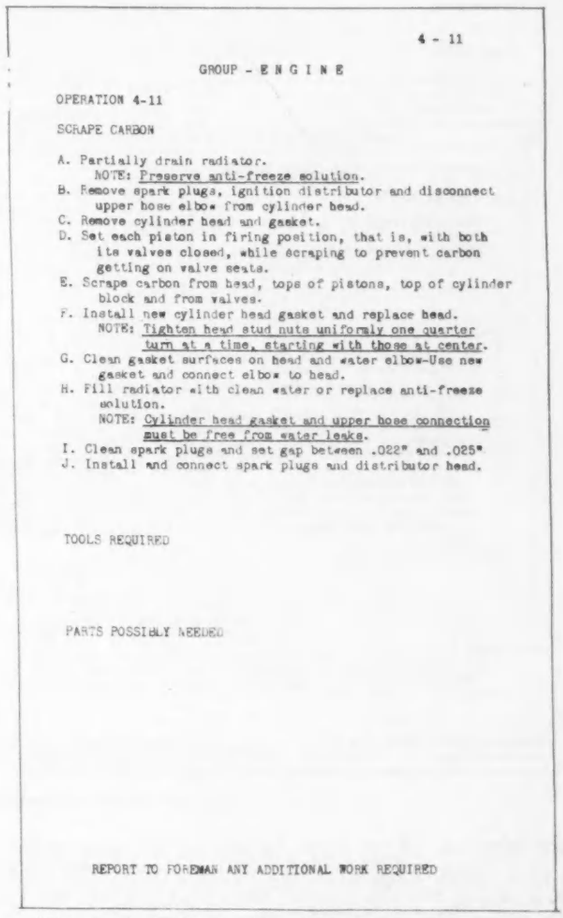
As the time-records accumulated, they were posted to individual sheets for the various operations. These summary sheets were checked over by the shop foreman and myself. Any time-records that were obviously too high or too low were rejected, and the average time required on each operation was determined. In the majority of cases, at least 10 valid reports were used in determining the average; in some cases, the number was more than 100.

Operation Data

It was decided to write-up the detailed procedure required on each operation, so as to

(1) Make definite the work required by each operation
(2) Outline the best procedure to accomplish this work
(3) Inform all mechanics of any shortcuts developed by anyone in the organization
(4) Enable a good mechanic not familiar with this particular car to adapt himself quickly to our particular methods
(5) Avoid the chance of having work ordered by an owner not being completely finished.
(6) Prevent arguments with the mechanics in case their work were incomplete or improperly done, because they must in such case complete it or do it again on their own time

A standard form was adopted for these operation sheets, the original being written on vellum. Carbon paper was used against the back of the vellum so that clear blue-prints measuring 6 x 9½ in., could be made in any quantity required. The working set of these blue-prints for use in the shop was mounted on steel plates, the prints being covered with shellac to preserve them indefinitely. These mounted prints are drawn out on tool checks as required by the workman.



4 - 11

GROUP - E N G I N E

OPERATION 4-11

SCRAPE CARBON

A. Partially drain radiator.
NOTE: Preserve anti-freeze solution.
B. Remove spark plugs, ignition distributor and disconnect upper hose elbow from cylinder head.
C. Remove cylinder head and gasket.
D. Set each piston in firing position, that is, with both its valves closed, while scraping to prevent carbon getting on valve seats.
E. Scrape carbon from head, tops of pistons, top of cylinder block and from valves.
F. Install new cylinder head gasket and replace head.
NOTE: Tighten head stud nuts uniformly one quarter turn at a time, starting with those at center.
G. Clean gasket surfaces on head and water elbow-Use new gasket and connect elbow to head.
H. Fill radiator with clean water or replace anti-freeze solution.
NOTE: Cylinder head gasket and upper hose connection must be free from water leaks.
I. Clean spark plugs and set gap between .022" and .025".
J. Install and connect spark plugs and distributor head.

TOOLS REQUIRED

PARTS POSSIBLY NEEDED

REPORT TO FOREMAN ANY ADDITIONAL WORK REQUIRED

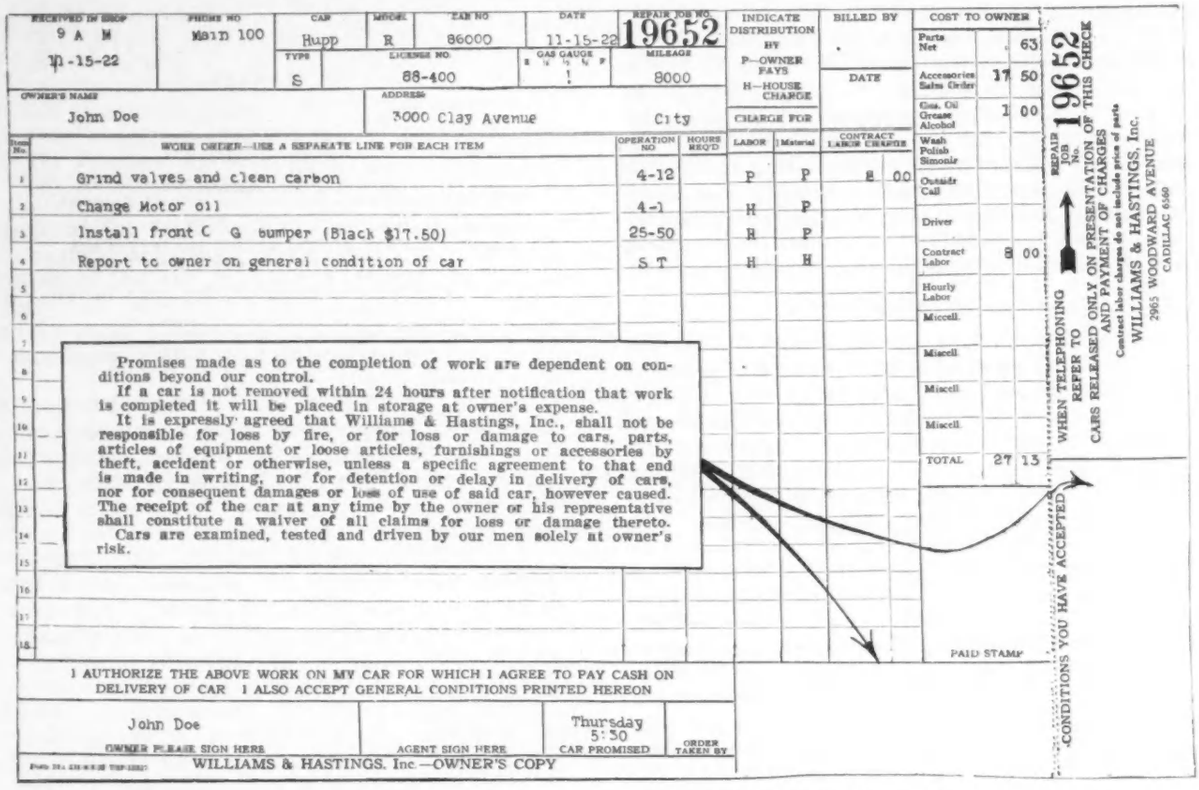
Fig. 1—A Typical Operation Sheet Giving the Various Steps That Are To Be Taken

A typical example of these operation sheets is shown in Fig. 1. The group number and name are stated at the top of this sheet, followed by the operation number and the name of the operation. The operation number is also placed in the upper right-hand corner of the sheet. The detail operations, with the necessary notes, are written in as definite terms as possible. It was found to be a difficult task to put these instructions into such form that they could not be misinterpreted even by the mechanic with little education. A space is provided below the instructions for a list of the special tools required and another space for a list of the parts most commonly required. Neither the tools nor the parts are filled-in on this sample sheet.

At the bottom of each sheet is a standard note: "Report to foreman any additional work rquired." Especial emphasis is laid on this in the shop, as points requiring attention frequently come to the workman's notice, although no mention has been made of them by the owner. Where such additional work is advisable in the judgment of the foreman, an effort is made to get in touch with the owner by telephone, to secure his authorization for the extra work. If it is impossible to reach the owner, the general rule is not to do the additional work; although in some particular cases, where the owner is well known to the service organization, the additional work is done if it is of relatively small amount.

Repair-Job Order-Form

After a process of development had been gone through, the repair-job order-form shown in Figs. 2 to 6 was



RECEIVED IN SHOP: 9 A M 11-15-22 | PHONE NO: Main 100 | CAR: Hupp | MODEL: R | CAR NO: 86000 | DATE: 11-15-22 | REPAIR JOB NO: 19652 | TYPE: S | LICENSE NO: 88-400 | GAS GAUGE | MILEAGE: 8000

OWNER'S NAME: John Doe | ADDRESS: 3000 Clay Avenue City

INDICATE DISTRIBUTION BY P—OWNER PAYS H—HOUSE CHARGE | BILLED BY | DATE | CHARGE FOR

Item No.	WORK ORDER—USE A SEPARATE LINE FOR EACH ITEM	OPERATION NO.	HOURS REQ'D	LABOR	Material	CONTRACT LABOR CHARGE
1	Grind valves and clean carbon	4-12		P	P	8 00
2	Change Motor oil	4-1		H	P	
3	Install front C G bumper (Black $17.50)	25-50		H	P	
4	Report to owner on general condition of car	S T		H	H	

COST TO OWNER

Parts Net	63
Accessories Sales Order	17 50
Gas, Oil Grease Alcohol	1 00
Wash Polish Simonize	
Outside Call	
Driver	
Contract Labor	8 00
Hourly Labor	
Miscell.	
Miscell.	
Miscell.	
Miscell.	
TOTAL	27 13

PAID STAMP

REPAIR JOB No. 19652 WHEN TELEPHONING REFER TO

CARS RELEASED ONLY ON PRESENTATION OF THIS CHECK AND PAYMENT OF CHARGES

Contract labor charges do not include price of parts

WILLIAMS & HASTINGS, Inc. 2965 WOODWARD AVENUE CADILLAC 6560

CONDITIONS YOU HAVE ACCEPTED

Promises made as to the completion of work are dependent on conditions beyond our control.

If a car is not removed within 24 hours after notification that work is completed it will be placed in storage at owner's expense.

It is expressly agreed that Williams & Hastings, Inc., shall not be responsible for loss by fire, or for loss or damage to cars, parts, articles of equipment or loose articles, furnishings or accessories by theft, accident or otherwise, unless a specific agreement to that end is made in writing, nor for detention or delay in delivery of cars, nor for consequent damages or loss of use of said car, however caused. The receipt of the car at any time by the owner or his representative shall constitute a waiver of all claims for loss or damage thereto.

Cars are examined, tested and driven by our men solely at owner's risk.

I AUTHORIZE THE ABOVE WORK ON MY CAR FOR WHICH I AGREE TO PAY CASH ON DELIVERY OF CAR I ALSO ACCEPT GENERAL CONDITIONS PRINTED HEREON

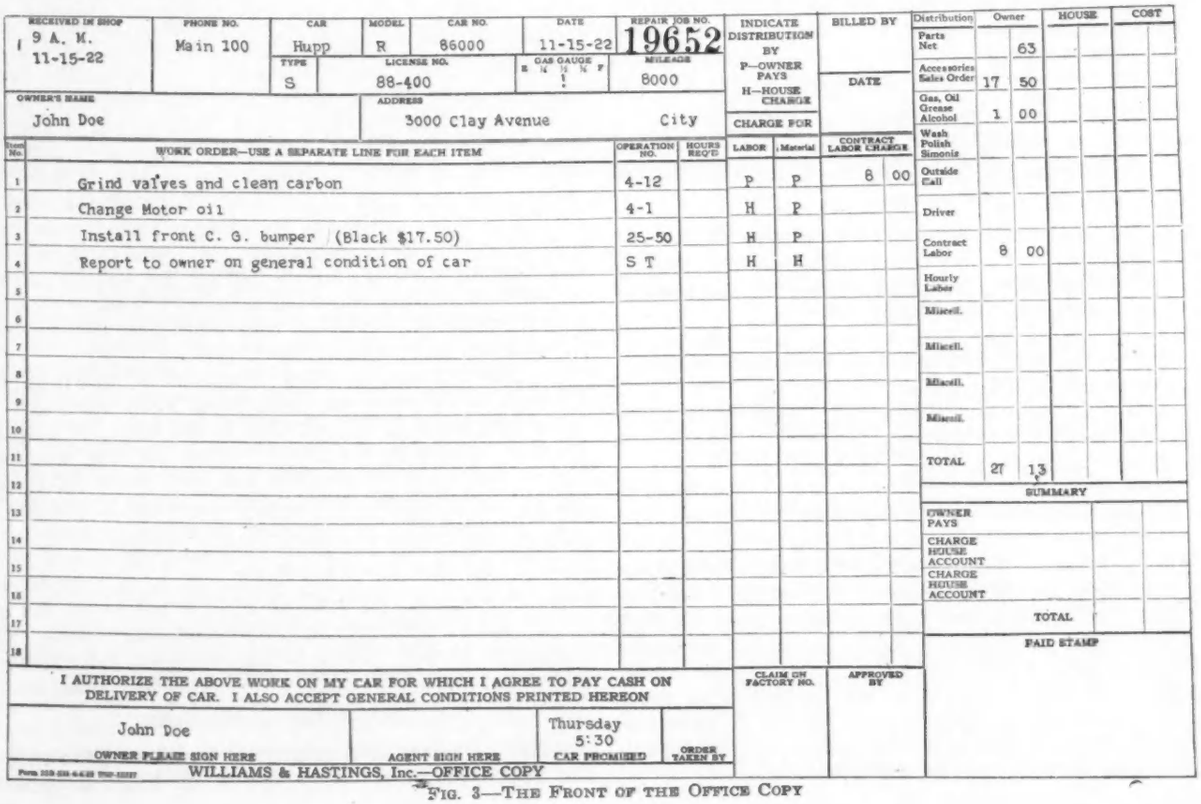
John Doe		Thursday 5:30	
OWNER PLEASE SIGN HERE	AGENT SIGN HERE	CAR PROMISED	ORDER TAKEN BY

WILLIAMS & HASTINGS, Inc.—OWNER'S COPY

FIG. 2—THE ORIGINAL OR OWNER'S COPY OF THE REPAIR-JOB ORDER-FORM

finally adopted. This form is printed in quadruplicate. The first sheet, Fig. 2, is the owner's copy; the second, Figs. 3 and 4, the office copy; the third, Fig. 5, the foreman's copy; and the fourth, Fig. 6, the shop copy that is used by the mechanic.

To carry the fourth copy on the car, a celluloid-faced cloth-envelope, open at the top, is provided. This protects the shop copy from grease and dirt while the work is in process. A detailed description of this repair-job order-form will not be attempted here, as the reasons for



RECEIVED IN SHOP: 9 A. M. 11-15-22 | PHONE NO.: Main 100 | CAR: Hupp | MODEL: R | CAR NO.: 86000 | DATE: 11-15-22 | REPAIR JOB NO.: 19652 | TYPE: S | LICENSE NO.: 88-400 | GAS GAUGE | MILEAGE: 8000

OWNER'S NAME: John Doe | ADDRESS: 3000 Clay Avenue City

INDICATE DISTRIBUTION BY P—OWNER PAYS H—HOUSE CHARGE | BILLED BY | DATE | CHARGE FOR

Item No.	WORK ORDER—USE A SEPARATE LINE FOR EACH ITEM	OPERATION NO.	HOURS REQ'D	LABOR	Material	CONTRACT LABOR CHARGE
1	Grind valves and clean carbon	4-12		P	P	8 00
2	Change Motor oil	4-1		H	P	
3	Install front C. G. bumper (Black $17.50)	25-50		H	P	
4	Report to owner on general condition of car	S T		H	H	

Distribution	Owner		HOUSE		COST	
Parts Net		63				
Accessories Sales Order	17	50				
Gas, Oil Grease Alcohol	1	00				
Wash Polish Simonize						
Outside Call						
Driver						
Contract Labor	8	00				
Hourly Labor						
Miscell.						
Miscell.						
Miscell.						
Miscell.						
TOTAL	27	13				

SUMMARY

OWNER PAYS		
CHARGE HOUSE ACCOUNT		
CHARGE HOUSE ACCOUNT		
TOTAL		

PAID STAMP

I AUTHORIZE THE ABOVE WORK ON MY CAR FOR WHICH I AGREE TO PAY CASH ON DELIVERY OF CAR. I ALSO ACCEPT GENERAL CONDITIONS PRINTED HEREON

John Doe		Thursday 5:30	
OWNER PLEASE SIGN HERE	AGENT SIGN HERE	CAR PROMISED	ORDER TAKEN BY

CLAIM ON FACTORY NO. | APPROVED BY

WILLIAMS & HASTINGS, Inc.—OFFICE COPY

FIG. 3—THE FRONT OF THE OFFICE COPY

LABOR					MATERIAL						MATERIAL				
DATE	OPERATION	WORK-MAN	TIME	ITEM	Quantity	PART No	NAME	P	H	AMOUNT	Quantity	PART No.	NAME	P	H	AMOUNT
		15			1	45215	Water header gasket			03						
		15			1	45148	Cylinder head gasket			60						
											Quantity	ACCESSORIES		P	H	AMOUNT
											1	A.C. 126 C. G. Bumper-Black				17 50
											Quantity	GAS, OIL, GREASE, ALCOHOL		P	H	AMOUNT
											1	Gallon cylinder oil				1 00
											PURCHASE ORDER No.	WORK SPECIFIED	COMPANY	P	H	AMOUNT

FIG. 4—THE BACK OF THE OFFICE COPY

RECEIVED IN SHOP: 9 A. M. 11-15-22 | PHONE NO: Main 100 | CAR: Hupp | MODEL: R | CAR NO: 86000 | DATE: 11-15-22 | REPAIR JOB NO: 19652 | INDICATE DISTRIBUTION BY P—OWNER PAYS H—HOUSE CHARGE

TYPE: S | LICENSE NO: 88-400 | GAS GAUGE | MILEAGE: 8000

OWNER'S NAME: John Doe | ADDRESS: 3000 Clay Avenue City | CHARGE FOR

No.	WORK ORDER—USE A SEPARATE LINE FOR EACH ITEM	OPERATION NO	CLAIM	LABOR	Material
1	Grind valves and clean carbon	4-12		P	P
2	Change Motor oil	4-1		H	P
3	Install front C. G. bumper (Black $17.50)	25-50		H	P
4	Report to owner on general condition of car	S T		H	H
5					
17					
18					

GET OWNER'S APPROVAL ON ANY ADDITIONAL WORK WHICH SHOULD BE DONE BEFORE STARTING THAT WORK

John Doe		Thursday 5 30	
OWNER PLEASE SIGN HERE	AGENT SIGN HERE	CAR PROMISED	ORDER TAKEN BY

WILLIAMS & HASTINGS, Inc.—FOREMAN'S COPY

FIG. 5—THE FOREMAN'S COPY

most of the notations are obvious. It probably will suffice to call attention to the claim-check at the right-hand side of the owner's copy, Fig. 2. This sheet is perforated so that the claim-check can be detached readily. In the space on the office copy, Fig. 3, corresponding to the claim-check on the owner's copy, are two columns for house charges and the cost of various items. These two columns carry data that are of no interest to the owner. The back of the office copy, Fig. 4, also carries two columns at the left-hand edge which correspond to the claim-check section of the owner's copy. These two columns provide for the entering of the date and the operation number; consequently, they do not appear on the owner's copy. The time column is not filled-in where an operation is specified, as the charge for any operation is a fixed amount. The time column is used only where straight-time work is done.

The repair-job orders are written-up in pencil, carbon paper being used between the sheets. Typewritten orders look neater, but to typewrite them would require the services of at least one more clerk and seriously delay getting work started and also the completion of the billing on those jobs that are finished at the end of the working day. It will be noted that the foreman's copy and the shop copy of the repair-job order-form are smaller than the other two copies. This is to avoid putting into the hands of the men in the shop information in regard to prices that is of interest only to the owner.

The repair-job order-forms are padded in lots of 25 sheets, and each of the service-salesmen is provided with a light wooden tray into which one of these pads fits. A piece of sheet aluminum, about 1/16 in. thick and the same size as the pad, goes with each one of these trays.

RECEIVED IN SHOP: 9 A. M. 11-15-22 | PHONE NO: Main 100 | CAR: Hupp | MODEL: R | CAR NO: 86000 | DATE: 11-15-22 | REPAIR JOB NO: 19652

TYPE: S | LICENSE NO: 88-400 | GAS GAUGE | MILEAGE: 8000

OWNER'S NAME: John Doe | ADDRESS: 3000 Clay Avenue City

No.	WORK ORDER—USE A SEPARATE LINE FOR EACH ITEM	OPERATION NO	WORK-MAN No.
1	Grind valves and clean carbon	4-12	
2	Change Motor oil	4-1	
3	Install front C. G. Bumper (Black $17.50)	25-50	
4	Report to owner on general condition of car	S T	
5			
17			
18			

REPORT ANY OTHER WORK REQUIRED TO FOREMAN | WORK ORD BY | FOR NOTES SEE OTHER SIDE

John Doe		Thursday 5.30	
OWNER PLEASE SIGN HERE	AGENT SIGN HERE	CAR PROMISED	ORDER TAKEN BY

WILLIAMS & HASTINGS, Inc.—SHOP COPY

FIG. 6—THE SHOP COPY OF THE REPAIR-JOB ORDER-FORM THAT ACCOMPANIES THE CAR ON ITS PROGRESS THROUGH THE SHOP

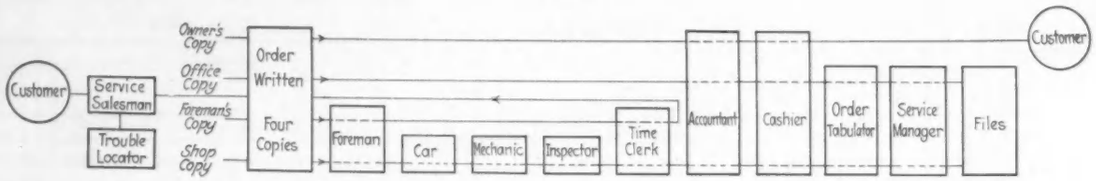


FIG. 7—DIAGRAM ILLUSTRATING THE ROUTING OF THE FOUR COPIES OF THE REPAIR-JOB ORDER-FORM

It is inserted under the fourth copy of the top repair-job order-form, to afford a satisfactory even surface for writing. If this were not provided, it would be difficult to write toward the right-hand end of the pad, because the pad tapers in thickness, due to the smaller size of the foreman and the shop copies.

ROUTING OF SHOP ORDERS

The routing of the four copies of the repair-job order is shown in the chart, Fig. 7. When a customer comes to the shop with his car to have some work done, he is met by a service-salesman who converses with him and thus determines what work is to be performed. If it is impossible to determine exactly what is to be done, a trouble locater is called into conference; if necessary, this man rides in the car to determine the exact nature of the work required, and he reports back to the service-salesman. This permits the service-salesman to be on the floor all the time.

Upon ascertaining the exact nature of the work to be performed, the service-salesman, by referring to his manual, shown in Fig. 8, quotes the price to be charged, and makes all arrangements with the car-owner as to whether he pays or the house shall pay for the transaction. Everything being satisfactory, he then writes the order in quadruplicate. Each operation is listed and priced and marked as to whether the customer or the house shall pay. All this is determined before the car goes to the shop.

OPERATION	PRICE
1	$2.40
2	3.20
3	9.60
4	5.80
10	8.00
22	6.90
30	3.30
31	5.80
32	2.00
33	.90

12

FIG. 8—A TYPICAL PAGE FROM THE SERVICE-SALESMAN'S MANUAL SHOWING THE PRICES CHARGED FOR CERTAIN OPERATIONS

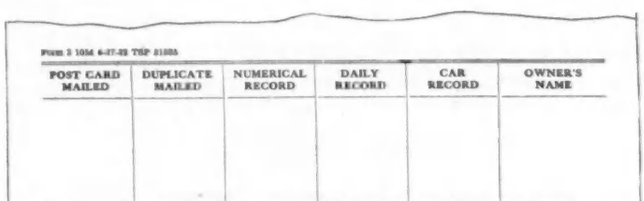


FIG. 9—FACE OF THE ENVELOPE THAT IS USED AS A FILE WRAPPER FOR A COMPLETE REPAIR-JOB ORDER

The owner's and the office copies are sent to the accountant; and the foreman's and the shop copies, along with the car, are sent to the foreman. The foreman sends his copy direct to the time clerk, who holds it as a follow-up. The shop copy is placed in a pocket attached to the radiator of the car, and it stays with the car until the job is finished.

The mechanic then performs the work outlined on the shop, or fourth, copy, and when it is finished he calls in the inspector who passes upon the work. If it is unsatisfactory, the mechanic makes the necessary corrections before the inspector will pass it. In addition to the inspection of the mechanic's work by the inspector, the foreman is called to look the job over before the

inspector. The inspector must place his O. K. on the shop copy of the job order before the car is released. This copy then goes to the time clerk, who stamps it to indicate that all time slips and requisitions have been sent through, matches up the shop copy with the foreman's copy and sends the latter back to the service-salesman. The shop copy is then sent to the accountant's office, where it is matched-up with the owner's and the office copies that are being held. In the meantime, all charges for straight-time labor, parts, accessories or outside work, have been filled-in on the owner's and the office copies as fast as the necessary information reached the accountant. When the shop copy reaches the accountant, he makes the final entries, totalling the various items and computing the charges to the house and to the customer. As soon as the customer's invoice is completed, the owner's, the office and the shop copies all are forwarded to the cashier.

The repair order is held by the cashier until the owner arrives and pays his charges. Then the cashier receipts the first or original copy, stamping it paid, and delivers it to the customer. The shop copy and the office copy are then sent to the desk of the order tabulator, where all information is compiled, and a complete statistical chart is made that covers the transaction. The order is then sent to the service manager, who thereby has complete knowledge of the nature of the work performed, the length of time required and the like. This keeps him in direct touch with the shop on all jobs. Afterward, he sends the order to be filed for future reference as a complete record of the transaction. The face of the envelope used as a file-wrapper is shown in Fig. 9.

Repair Parts

If, during the course of the repair work, it becomes necessary to install new parts, the mechanic who does the work notifies the time clerk; the latter makes out a store's requisition in duplicate, as shown in Fig. 10, listing the names of the material desired. Both copies are sent to the parts department, as shown in the left hand of Fig. 11, where the part number and the price are inserted on both copies and the order filled by the stockroom. The parts clerk then delivers the original to the accountant, who attaches it to the customer's order and enters the prices on the customer's invoice and the office copy. The duplicate of the store's requisition is given to the stock-record keeper, who makes the necessary entry on the stock-record card. If it becomes necessary to have work done outside of the repair-shop, or to order parts that are not carried in stock, the same stores requisition is used and sent to the purchasing agent, who takes the necessary steps to see that it is taken care of immediately.

It happens occasionally that more parts are drawn from the stockroom than are required for the particular job. In this case a receiving memorandum, shown in Fig. 12, which is printed in duplicate, in red, is filled-out by the time clerk and returned with the surplus parts to the stockroom. One copy, when filled-in with the part numbers and the price, goes to the accountant; the other copy goes to the stock-record keeper. The necessary entries are made by each on the repair-job order-form and the stock-record cards. The routing of the stores requisitions and that of the time slips is shown diagramatically in Fig. 11.

Timekeeping

To keep the time records for each man properly, a special form was developed as shown in Fig. 13. This

11/15/1922 DATE	WANTED	SUPPLIES	19652 R. J. O. No.	
QUANTITY	PART NUMBER	DESCRIPTION	PRICE	AMOUNT
1	AC 126	C. G, Front Bumper - Black		17 50
1.	Gal.	Cylinder Oil		1 00
1	45148	Cylinder Head Gasket		60
1	45215	Water Header Gasket		03
J. A. S. APPROVED BY	S. M. STOCK ISSUED BY	S. M. PRICED BY	X POSTED	

FORM 2 10M 9-10-22 CBS P888 **STORES REQUISITION** WILLIAMS & HASTINGS, INC.

Fig. 10—Requisitions for Parts Needed by the Shop Are Written in Duplicate on This Form

form is printed in quadruplicate, on one sheet of paper; two copies of the form appear on each side of the sheet, and they are spaced in such a way that, when folded, the four copies register with each other. Three sheets of carbon paper are used; so, all the records of time required are made at the one writing. The first and second copies are perforated so that the individual slip, giving the time for each operation, can be detached.

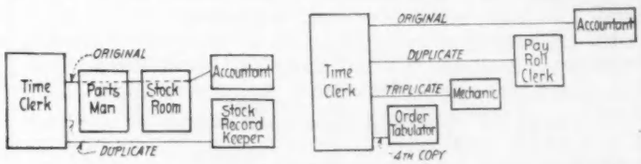


Fig. 11—The Routing of the Stores Requisition, Reproduced in Fig. 10, Is Shown at the Left and That of the Time Slips, Reproduced in Fig. 13, Is Outlined at the Right

In practice, the time slips are made out in pencil by the time clerk. The time is stamped on the clock by the time clerk, who is notified by the mechanic whenever he starts or completes an operation.

When a man starts on an operation, he reports the repair-job order-number and the operation number to the time clerk, who makes the necessary entries on the slip. When the man completes this operation he again reports to the time clerk, who stamps the previous operation completed and rings the man in on the next opera-

WILLIAMS & HASTINGS, INC
DETROIT, MICH.
RECEIVING MEMO NO. 7167
RECEIVED FROM
PURCH. ORDER NO.
DATE
QUANTITY | NUMBER | ARTICLE | PRICE | EXTENSION | TOTAL
RECEIVED BY CHARGE ACCT. APPROVED BY
RECEIVING MEMO.

Fig. 12—Where More Parts Are Drawn from the Stockroom than Are Needed, the Surplus Accompanied by a Receiving Memorandum Are Returned

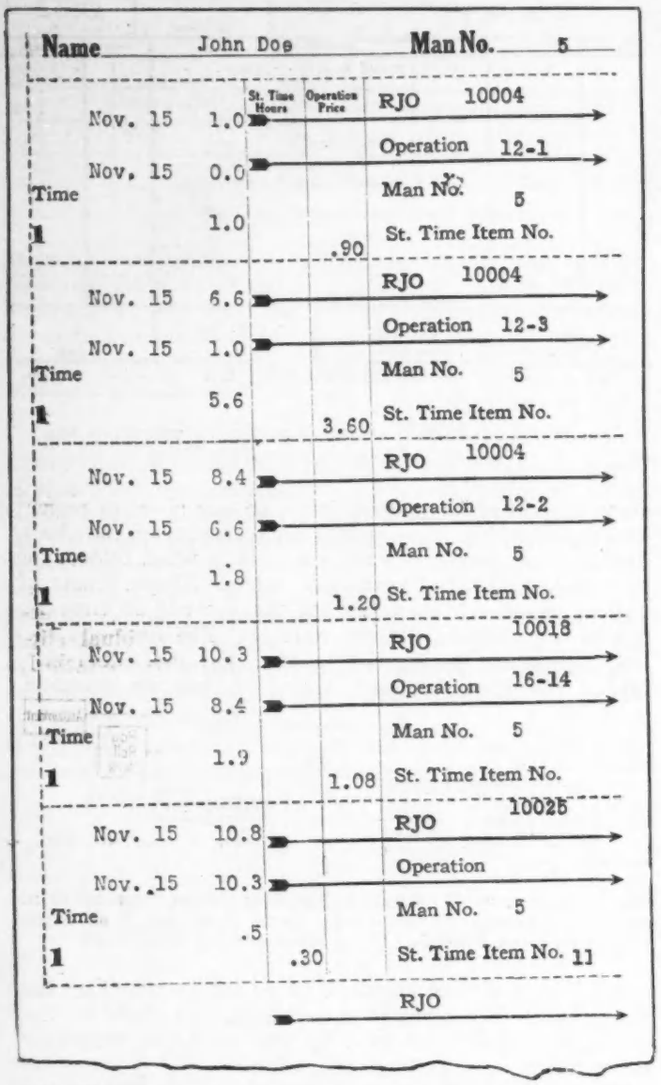


FIG. 13—SPECIAL TIME-RECORD SLIPS, PRINTED IN QUADRUPLICATE, ARE USED TO KEEP TRACK OF THE TIME SPENT ON A PARTICULAR OPERATION

tion. The time clerk then computes the elapsed time for the completed operation and notes it on the time slip.

In the case of a contract-labor operation, he inserts the amount to be paid the man in the column headed "operation price." If the particular operation is one based on straight time, he multiplies the elapsed time by the workman's straight-time rate and inserts the figure under the heading, "straight-time hours." As each operation is completed, the perforated copies are detached; one is sent to the accountant, who enters the charge on the repair-job order, and the other is sent to the shop foreman or service manager, who can thus follow the progress of the work. It also enables the foreman or service manager to check quickly any time taken on a flat-rate operation that varies greatly from the established average. In case of such extreme variation, an immediate investigation is instituted to ascertain whether the work has been done properly or why the man has required so much time on that particular job. The third copy of the time slip is sent to the payroll-clerk at the end of each day, who tabulates the amount due each man. The fourth copy is given the individual mechanic, so that he can check-up the amount due him in case there is anything wrong.

In the event of some condition arising over which the mechanic has no control, whereby a job cannot be performed in the allotted time, it is the duty of the foreman or service manager to make a thorough investigation; and, if he deems it advisable, the mechanic can be transferred to straight time for the particular job. For example, if an owner's car is brought in to have the valves ground, and if the mechanic should strip one of the studs when tightening down the cylinder-head in assembling, while using the proper tools, he should not be held responsible; in this event, his day-rate time should be allowed him in making the necessary repairs. On the other hand, if the car came into the shop for valve-grinding and it was found that it was necessary to install new valves and make repairs to the cylinder valve-seats other than ordinary reaming, it would then be necessary to ask the owner for his permission to make an additional order covering this operation. When a mechanic is working on straight time, he is paid his regular hourly-rate as recorded on the payroll. Not all the mechanics in the shop receive the same hourly-rate but, when doing contract work, they all receive the same amount of money for the same job.

All operations on which a contract has been made and a price allowed for doing the work are posted in the shop; so, when a mechanic is assigned to a particular job he can tell instantly exactly how much money he will receive for the work by referring to the bulletin-board. On the same bulletin-board are also listed, in red, the jobs on which a minimum time has been established, and the mechanic must not perform the work in less time than this, because experience has proved that to do so only means the slighting of the work and the possibility of having to do it again. There are but few of these jobs, however; they consist of those cases in which inspection after the job is done is difficult or impossible.

At this point it is well to note that, with the exception of the minimum time mentioned, the workman views the various operations strictly from a dollars-and-cents point of view. He knows from the lists how much money he is to be paid for each operation and proceeds to earn that money with as little delay as possible. The actual time allowed for each operation is not listed in the shop, nor is it discussed with the men. The master list is filed in the service-manager's office.

The service-salesman must be thoroughly familiar with the mechanical structure of the car, and also with the work apt to be required on it. He must also familiarize himself with the operations that have been listed and written out in detail. For this reason he is furnished with a complete set of the operation sheets arranged in order, in loose-leaf binders. For ordinary use, while he is writing-up orders, he is provided also with a loose-leaf binder containing only a complete set of the index sheets to the operation sheets. He has in addition a small loose-leaf notebook which contains a complete list of the operation numbers and the customer's price for each. A typical sheet from the notebook is shown in Fig. 8.

PRICE REVISION

The time required for all contract operations is recorded each day on summary sheets, a sample of which is shown in Fig. 14. About once a month the average time for each operation is checked-up. If the time has changed materially from that on which the contract rate is based, the service manager and the statistician discuss the situation with me and a decision is made regarding changes

in the contract price to the customer and also in the piece-work rate to the mechanic. If it is found that work can be performed in much less time than that on which the contract rate is based, it is to the advantage of the house to reduce prices, although we bear in mind that it is unwise to cut the mechanic's time so low that he cannot earn more money doing contract work than he can at his established day-rate. He must have the incentive to do good work in the proper time, and this can only consist of increased earnings.

Our experience has shown that the men's average earnings have increased from about 65 cents per hr. under the old straight-time methods to about 81 cents per hr. on the piece-work plan. At the same time, the output per man has been increased about 40 per cent. When rate revision was last considered, it was found that there were five operations on which the rates should be lowered, and the same number on which the rates needed to be increased. These changes met with no opposition from the men in the shop, as they appreciate that these revisions are all fair to them. This is indicated by the above statement in regard to the last rate-changes.

Control Chart

To obtain the best results from the flat-rate and piece-work system, we found it desirable to employ a control sheet so as to picture clearly, for the service manager, the results being obtained. Among other items which are tabulated daily are the

(1) Number of repair-jobs completed
(2) Number of operations performed
(3) Number of repair orders performed in each hourly time-group
(4) Average number of hours per repair-order
(5) Total amount collected for repair work
(6) Average amount collected per repair-order
(7) Total house-charges on repair-orders
(8) Number of hours on contract work
(9) Number of straight-time hours
(10) Ratio of straight time to contract time
(11) Ratio of productive to non-productive labor
(12) Time spent on guarantee or policy work

It is not absolutely necessary that this control chart be used, but some of the small points that require correction are apt to be passed unnoticed if some such chart is not used. For instance, any repair-order put into the shop on which less than 2 hr. of work is specified is a losing proposition, due to the amount of overhead that must be charged against each repair-order. It is unavoidable that some small orders go into the shop, but the service-salesman should be coached to endeavor to sell additional work to those owners who come in only

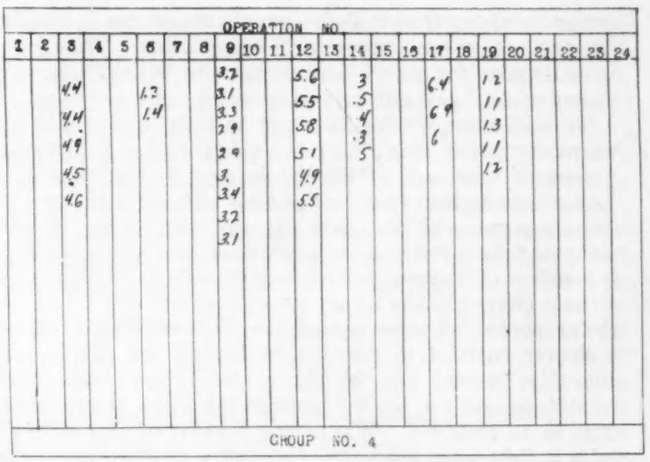


Fig. 14—Summary Sheet on Which the Time Required for All Contract Operations Is Recorded

for one or two small jobs. If the number of short-time jobs could be decreased greatly it would be possible to reduce contract-rate charges materially on the jobs that run to more than 2 hr. of time.

Limitations of the Flat-Rate and Piece-Work System

The combined flat-rate and piece-work system can be used satisfactorily only in those shops that are large enough to warrant the installation of a timekeeper and a suitable accurate time-clock. If the number of men employed or the varying volume of repair work does not warrant the employment of a timekeeper, it is useless to attempt to put in piece-work. Regardless of the size of the shop, the flat-rate system of charges to the owner should be adopted. At the present time, owners will never be satisfied until they know in advance what the labor on their car is going to cost them. A service manager who makes a note of the owners' requirements on the back of an old envelope is probably a good scout, and he intends to be perfectly fair, but his assurance to the owner that "the charges will be all right" is far from satisfactory to the owner. To illustrate now the same repair-order can be used to advantage in a small shop, the chart shown in Fig. 15 has been prepared. This shows the number of non-productive men very considerably reduced, although the same procedure is followed as in the large shop.

Guarantee or Policy Work

The new car-guarantee used by the builder of the car I represent is the same as that used by practically all other motor-car companies. In a brief general way we interpret this to mean that we will make right for the

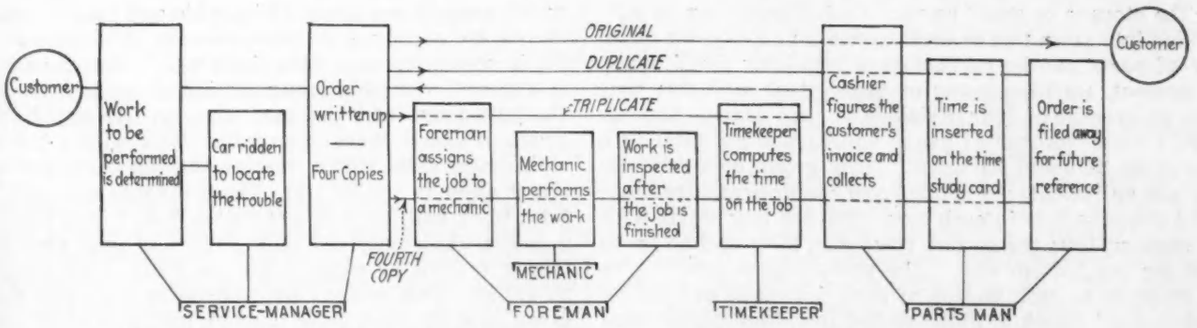


Fig. 15—Chart Illustrating the Application of the Repair-Job Order-System to a Small Shop

owner anything that is defective about the car for which the factory or our company is responsible. This guarantee applies for a period of 90 days to the original purchaser of any new car sold at retail by our company.

To enable the service-salesman to pass intelligently on claims for policy work, he is provided with a list of purchasers of new cars. This list is kept in the form of a visible tube-index, each line giving one car-number, the owner's name and the date of purchase. This is kept uptodate; the names of owners whose cars are more than 4 months old are removed periodically. Policy work without charge to the owner is not confined strictly to the 90-day period, as cases sometimes arise where the owner is clearly entitled to relief even though the car is considerably beyond the 90-day period. Such cases are usually passed on by the service-salesman if no great expense is involved. Where the justice of the owner's claim is debatable, the service manager is asked to handle the matter.

Parts Department

The equipping and handling of the parts department has required intensive study along the several lines of

(1) Storage of parts
(2) Parts records
(3) Purchasing
(4) Shipments
(5) Deliveries

The fundamental rule adopted in regard to the storage of parts is to have a specific location for each different part and, under no conditions, to have more than one kind of part in a given location. The equipment used to secure this result consists of stock-bins of various sizes, steel cabinets each containing 60 steel drawers, racks for such articles as fenders, bumpers and springs, and shelves for certain miscellaneous articles. The stock-bins are made in sections and constructed of wood with ¼-in.-mesh wire-screen for the back. The sections are from 5 to 6 ft. long and about 3 ft. high; the depth varies from 12 to 16 in. These sectional bins are arranged in groups of 12; 4 of the 16-in. sections form the base, there are two layers of four 12-in. sections each on top of this base, the upper layer consisting of bins 6-in. wide for smaller parts. Each section of these bins is given an identifying letter, and a standard numbering-system for locating the bins in each section has been adopted. Each bin carries on its face a card showing the part-number of the piece in that particular bin. Wooden bins were adopted because, 3 years ago, the modern steel bins were still in the development stage. If new equipment were being purchased at present, it is probable that the steel bin would be the better, although, in case it is necessary to shift the locations of bins, the sectional wooden construction has a decided advantage.

The steel cabinets, each carrying 60 drawers, are ideal for the storage of small parts. Each drawer can be subdivided into from two to eight sections; so, a great quantity of parts can be carried in a relatively small space. At present, we have seven of these steel cabinets; they have an average of four divisions to each drawer and can store a total number of parts approximating 1700 in a floor-space of about 21 sq. ft. This group of steel cabinets has an identifying symbol and the drawers are numbered consecutively in each row. The top row starts with the number 100; the second row, with 200; and so on to 1500 for the bottom row. The part-number applying to the material in each section of each drawer is printed on a white card which is glued to the partition or the back of the drawer as required.

The gasket boards on which gaskets, switch keys, shims and similar small parts are mounted, are made of 1¼-in. tongue-and-groove lumber, faced with beaverboard, which is painted black. Cornice hooks, ranging in length from 2 to 7 in., depending upon the size and number of the articles to be supported, are screwed into this board. The racks were designed in each instance to suit the particular material to be stored. The racks for springs, bumpers, axle shafts and similar parts, each consist of two 4 x 4-in. timbers, set on-end and bolted solidly to the wall. Pieces of ½-in. steel-rod are imbedded in pairs, in these 4 x 4-in. timbers at intervals of from 4 to 10 in., the length of the pins projecting from the timbers varying from 6 to 12 in.

The fender racks consist of a frame work of 2 x 4-in. lumber supporting narrow wooden shelves on which the ends of the fenders can rest. The fenders are carried in the same position as that in which they are mounted on the car, each adjacent pair of racks carrying corresponding right and left fenders, the left-hand rack in each case carrying the left-hand fender. This permits the fenders to be nested one above the other with very little waste space, and practically eliminates any scratching of the enamel.

Special racks for carrying valves, piston-rings and similar parts, have been made as required. The piston-ring rack, for instance, consists of a heavy wooden support, on which are mounted cylindrical wooden blocks of such a size that the piston-rings just slip over them. Provision is made at one side of this rack for carrying the standard and over-size inspection gages. Every piston-ring is checked with these gages before it is sold or delivered to the shop, to eliminate any chance of the wrong size of ring being delivered.

The location of the bins, cabinets and the like has been studied with a view to saving steps for the men in the parts department as much as possible. Those parts for which there is the greatest call are located within a few feet of the sales-counter. This study has resulted in eliminating the services of one stock-clerk entirely.

Parts Records

A parts department of any size involves the keeping of stock records which show stock on order, stock on hand, sales and the like. In other words, the records form a perpetual-inventory system.

We struggled with the ordinary vertical card-file, thoroughly indexed, for 2 years. We found that cards were occasionally misfiled, resulting in great delay and confusion; also, that the cards themselves became crushed and dirty along the upper edge. To overcome these conditions, we installed a loose-leaf stock-record system about a year ago, each sheet being approximately 12 in. wide and 6 in. high. These sheets are carried in special ring-binders which are about 13 in. wide and 16 in. long. The sheets are arranged in these binders in groups of 15 to 20, in such a manner that the lower ½ in. of each sheet is exposed. On this lower section of each sheet appear the part name and the part number. In front of each group of sheets there is an index sheet with a tab on the right-hand side, which carries the part number of the upper sheet in the group. These binders are each about 4 in. thick and, as they are rather heavy, are handled in a special desk provided with rollers so that they can be moved toward or away from the clerk with practically no effort. This system enables the record sheet for any given part to be located almost instantly, and entirely eliminates the chance of a sheet being lost or misfiled,

as the sheets remain permanently in place in the binders while all posting is being done.

To facilitate the locating of parts when the part-numbers are known, a tubular visible-index system has been installed. This consists of a rotary stand on which are mounted about a dozen, two-column, double-faced, panels, carrying about 90 celluloid tubes to each column. In each tube is inserted a typewritten slip carrying a part-number and its corresponding location. These part-numbers are, of course, arranged in numerical order. Indexing is accomplished by using celluloid tubes of twice the usual width, in which green or other colored slips with large figures are inserted. This index is readily kept uptodate, easily accessible and avoids the constant handling of stock-record cards required when the cards must be consulted to determine locations.

Purchasing

The purchasing of parts from the factory is based generally on the maintenance of stock, between certain minimum and maximum limits. We intend to have on hand any part for which there has been a single call in the last 6 months and, at the same time, we do not wish to have more money invested in the parts than is necessary. In accomplishing the above results, the minimum has been established at 1 month's supply, this figure being the average of the disbursements for the preceding 3 months. The maximum is established at 1½ times the minimum. Working to these figures involves the checking of the minimum for each part at the first of each month. It also involves the checking of the stock on hand against the minimum and the maximum, by the stock-record clerk, each time an entry is made in the stock-record. If the quantity on hand is too high or too low on any part, a report is made to the manager of the parts department, who sees that the necessary purchase-order is written and the stock secured.

A departure is made from the minimum or maximum mentioned when it is advisable in the judgment of the parts-department manager. For example, certain parts are sold by the factory in standard packages of 25 or 50. It is much better to buy the standard package, even though the quantity runs over the maximum, as it simplifies the handling at the factory and does not result in a greatly increased investment. Again, there is a seasonable variation in the call for certain parts, such as skid-chains. The big demand for these occurs in November and December and, if we work to the minimum established on the basis of August, September and October sales, the stock would be entirely inadequate. On the other hand, if the stock of skid-chains in February were based on sales in November, December and January, it would result in the carrying of a large inventory through the summer which is, of course, entirely unwarranted. Another factor influencing the purchase of accessories is the variation in discount with the size of the order. Careful attention and extremely good judgment are required in purchasing such material, if excess stock and possible loss, due to price changes, are to be avoided.

Shipments and Deliveries

Shipments of parts to dealers or other out-of-town purchasers are made ordinarily the same day on which the order is received, or at least on the following day. Special attention is given to telegraphic orders immediately upon their receipt. Large articles, such as fenders and radiators, are carried crated, ready for shipment, thus avoiding the delay incident to crating and packing.

The parts department is located on the first floor, and the shop is on the floor immediately overhead. A basket parcel-carrier, such as is used in shoe stores, was installed. By means of this requisitions, time-slips and the like are sent from the shop to the parts department, and any parts weighing not over 10 lb. and of reasonable size are delivered automatically to the shop without requiring a mechanic to leave his work and without requiring a messenger. Retail purchasers of parts are served over a long counter; at one end of this the cashier's desk is located. The parts-department organization has been

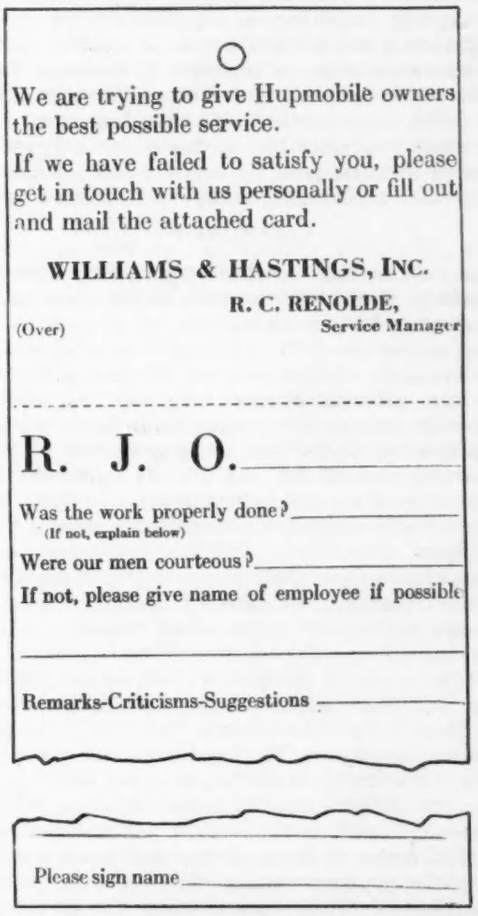

We are trying to give Hupmobile owners the best possible service.
If we have failed to satisfy you, please get in touch with us personally or fill out and mail the attached card.
WILLIAMS & HASTINGS, INC.
R. C. RENOLDE,
Service Manager
(Over)
R. J. O.
Was the work properly done?
(If not, explain below)
Were our men courteous?
If not, please give name of employee if possible
Remarks-Criticisms-Suggestions
Please sign name

Fig. 16—This Tag Attached to the Steering-Wheel of Each Car That Leaves the Shop Provides a Means for Following-Up Repair Work

taught that promptness, courtesy and cleanliness are just as essential in the parts department as they are in the shop or service-department proper. The result is that the personnel is up on its toes, striving to satisfy the customers at all times.

Follow-Up on Repair-Jobs

Various methods have been tried for following-up repair-work, to make sure that the owner is satisfied. The reply postal-card, mailed a day or two after the owner has taken his car, was tried for several months but did not prove very satisfactory. We next attempted to have the service-salesman telephone each car-owner a day or two after he had driven away. This proved impracticable, as frequently three or four telephone calls would fail to reach the owner. It was likewise expensive, in both telephone bills and the time required of the

service-salesmen. At present, the form shown in Fig. 16 is used. This is printed on fairly heavy tag-stock, and has a wire for attaching it to the steering-wheel. The repair order-number is filled-in by the inspector when he approves the work; and the tag is attached to the car. The tag is perforated so that the larger portion, when detached, constitutes a postal-card. Each one of these carries a 1-cent stamp; so, all the owner has to do is to fill-in and sign the card and drop it into a mail-box.

In the effort to give the personal touch to this follow-up, the cards are addressed to our service manager, and all of them are scrutinized by him when received. If the owner reports anything unsatisfactory, an immediate investigation is made. The owner is asked to bring his car in again as soon as possible if the dissatisfaction concerns some mechanical feature. The fact that the card is called prominently to his attention when he takes his car away impresses him with our earnestness in trying to give the best possible service, and results in getting a greater percentage of replies than other methods.

Cleanliness

The one thing that can build-up in an owner's mind, more quickly than anything else, a prejudice against a service-station, is to have his car delivered to him in a dirty or greasy condition. Imagine a lady who wears white gloves driving her car away from a service-station and finding, after a block or two, that her gloves are covered with grease. Or, suppose this same lady has on a white summer dress and, on getting out of her car, finds that the back of it is anything but presentable. No matter how good the mechanical work may have been or how courteous the men, you immediately have a dissatisfied customer.

We have taken extreme measures in endeavoring to deliver cars that are satisfactory in this respect. Mechanics are required to wear clean overalls. To assist in enforcing this regulation, our company stands the expense of washing all mechanics' overalls or shop coats. We also buy these garments in fairly large quantities and sell them to the men at cost. To protect the more or less delicate upholstery in closed cars, the men are required to cover the seats with clean cloths before entering a closed car. After a car is marked O.K. for delivery to the customer, it is inspected both inside and out, and any necessary cleaning is done. Particular attention is paid to the upholstery, the steering-wheel and the handles of all control levers. This work requires the services of at least one additional man, and at times two men, depending upon the volume of work going through the shop. We believe this expense is well justified; in fact, that this service must be rendered if satisfactory relations with customers are to be maintained.

General Results

After having used the flat-rate system for something over 1 year and the piece-work system for about 6 months, we are thoroughly sold on both. If we were to organize a new service-station today, we would immediately concentrate on obtaining the necessary data to install both of these systems. In fact, we would guess as closely as possible at the probable time-requirement of each operation and figure the corresponding charges to customers and the piece-work rates to the men, putting this system into operation at once and making any necessary adjustments as rapidly as possible in the light of experience.

As mentioned, the production per man has been increased about 40 per cent and the men's earnings have increased about 25 per cent. This 40-per cent increase in production covers the total production in the shop, regardless of whether it is on a piece-work or a straight-time basis. Of the total shop-time recently, between 50 and 60 per cent has been on the piece-work basis. We estimate that if we reach a basis of 75 per cent piece-work and 25 per cent straight-time, we will have attained the maximum.

If the operations now done on piece-work are considered alone, the production per man has increased very much more than 40 per cent. As an example of the decrease in the time on a given operation, we might mention the installation of bumpers. When this was done on straight time, the average cost to us in direct wages to the man was about $0.85. The piece-work rate for this same bumper-installation at present is $0.30. This is only slightly over one-third of the former charge, and yet the men are making more money per day.

We have always taken the attitude that we have no secrets in our business. Anything that we can tell to a competitor that will be of assistance to him in raising the plane on which his business is conducted will, in the long run, be of assistance to us through helping to change the mental picture carried by the average car-owner. Our service organization has spent many days in explaining to representatives of other factories and other dealers how and why we do various things. We expect to continue this policy and are always glad to have anyone seriously interested in these problems call on us and spend as much time with us as he wishes. We have had many requests for information by mail, but have discouraged this as much as possible. It is very difficult to give a picture in writing of any one phase of the service problem, as they are all so intimately related.

Automotive-Service Cooperation Between Manufacturer and Dealer

By J. F. Page[1] Chicago Service Meeting Paper

STATING that the kind of service cooperation needed between the manufacturer and the men in the field is the type that assists and encourages as well as supervises and dictates, the author comments briefly on varied phases of the subject. Among these are the importance of familiarity with conditions in the field, the type of factory field-representative desirable and the necessity of keeping him posted on all changes in design and adjustment.

Stock-department supervision is an important factor, as a check against over-stocking by dealers, and the advantages of standardization and interchangeability of parts are re-stated. Great emphasis is placed upon the desirability of rigid final car-inspections and accurate adjustments at the factory, before the cars are delivered to the dealers. The holding of periodic service-meetings is mentioned as an essential part of the duties of the factory service-department.

I DO not agree with those service-men who, in effect, would say to a manufacturer: Leave us alone, we have troubles enough. The manufacturer can be of real assistance to the dealer in regard to service problems; he certainly should be interested just as much in seeing that the proper service is being given as he is in the sales problem, since one is inseparably tied-up with the other. The kind of service cooperation needed between the factory and the men in the field is the kind that assists and encourages as well as supervises and dictates. Too often the best results are prevented and progress blocked by a factory policy of stern dictation or, worse still, the having of no definite service policy or standards. A definite policy should be established by the manufacturer, that is understood and lived up to by the dealer.

There are service problems peculiar to the size of the dealer's organization and territory just as there are sales problems. Again, there are problems common to all and only an open-minded and intelligent factory service-department can give the constructive cooperation needed to accomplish definite and satisfactory results. The factory service-organization should be striving constantly for better service to the car-owner, and there are definite ways in which the service-men in the field can be assisted and service to the customer improved.

Field Conditions

To accomplish anything worthwhile the factory must be familiar with the conditions in the field. Such knowledge can be obtained only at first hand; that is, by personal contact with the service-man and an appreciation of his problems. This means that factory representatives must travel over the territory. The first essential to their success is that these men have the right personality to size-up those with whom they come in contact and know how to deal with them. This is work that requires patience, tact, a thorough knowledge not only of the mechanical features of the particular car but of service problems in general, proper methods of stock-keeping, layout, organization and the like, together with the ability to apply such knowledge to conditions as they find them. Where service is carried on through large branches, the work of supervision and assistance may be divided among specialists, but the representative who covers a large territory comprising many dealers needs to be a very versatile individual to get the maximum in results and accomplish a real improvement in service. Such men should have a training made up of both field and factory experience.

Suggestions sent to the factory should be acknowledged promptly and considered carefully. The engineering department especially should be liberal in the attention given to such suggestions as properly may be made to that department. Nothing stifles initiative and constructive suggestions so surely as a policy of disinterestedness or actual antagonism on the part of the manufacturer. Out of many suggestions offered, only one may be worthy of adoption; but that one may be so good as to make worthwhile the time and trouble of treating all the others in such a way as to encourage the interest and the loyalty of the men in the field. Further, the manufacturing and the engineering departments should be careful to keep the men in the field accurately posted on all changes in design or adjustment, and some system is necessary for sending out such information in letters or bulletins. The dealer, in turn, must see to it that this information reaches all those in his organization who should receive it.

The dealer and the manufacturer will benefit from a spirit of open-mindedness and mutual assistance, yet such a spirit is far from universal today between factory and dealer organizations. With out the proper spirit of cooperation, neither the manufacturer nor the dealer will make the most of the opportunities at hand. The manufacturer should maintain a cost department containing accurate data on parts costs, and the prices of parts should be stabilized and listed in parts-books clearly and intelligently arranged. Much time and money can be saved or lost, depending on whether these lists are constructed properly.

Stock-Department Supervision

Supervision of stock departments is very important. Improper stock-keeping methods and inefficient stockmen are a prevalent source of loss and a great handicap in rendering good service. The stockroom should have close attention from both the manufacturer and the dealer. It is of no lasting advantage to the manufacturer to have a dealer who loads up with unnecessary parts, and certainly the man whose money is in the business does not want to carry a heavy, slow-moving stock; yet, I repeat, this department of the business is woefully neglected, and is a source of much loss. There certainly is no use in expecting an efficient and profitable parts-department so long as the management and responsibility are delegated to an inefficient man or boy at low wages.

The factory stock-department also can assist the dealer

[1] General manager of service Packard Motor Car Co. of Chicago, Chicago.

greatly by arranging to dispose of obsolete parts that have accumulated through no fault of the stock-keeper. The factory should be able to inform the dealer's stockman in regard to the necessary parts and amount of stock to carry, with reference to the number of cars of given model in the dealer's service territory. Thus, again, the top-heavy inventory will be avoided and, at the same time, the necessary variety of parts for proper service will be in the stock-bins.

Standardization and interchangeability of parts are of such obvious advantage in giving good service and in making possible a smaller parts-stock as scarcely to need any urging upon the manufacturer, yet many an exasperated service-man will say that his life would be easier and the service better if much greater care and attention were given these problems by the engineering and the manufacturing departments.

Through collaboration with the service-stations, definite standards of work and job specifications, together with time-studies, can be worked-out at the factory for practically all shop operations. This work naturally will include an investigation of shop methods, the designing of special time-saving tools and the like. The results of all this will be the standardizing of service to the car-owners, an increase in shop efficiency and a corresponding lowering of costs; and it will make possible the establishment of flat prices for service work. Nothing is more clearly needed in the automotive industry than a universal custom of quoting definite prices for repairs. It is possible to accomplish this, and it must become a fixed policy in the service methods of every successful distributor.

Factory Car-Inspections

Too much emphasis cannot be given to the matter of final inspections and adjustments at the factory before cars are delivered into the dealers' hands. The new owner's first impressions are often the lasting ones, in regard to the car and to the company back of it. It should not be necessary or expected of the dealer that he spend a big slice of his profit in getting cars ready to deliver in only such standard condition as the manufacturer himself would want to have his cars delivered to owners.

A very necessary part of the duties of the factory service-department is the periodic holding of service meetings. These should be conducted carefully and follow a definite program of an instructive and constructive nature, giving plenty of opportunity for the free exchange of ideas on every problem. There are plenty of problems with which the many-sided service-man is faced.

It is not to be inferred from these remarks that the manufacturer is expected to assume entire responsibility for the quality of service rendered by his dealers, nor is it even faintly suggested that the service-man is without shortcomings in many cases. There is much room for improvement in service everywhere, and not nearly enough attention is given this phase of the sales problem. Any distributor who expects lasting success has a perverted sense of values if, after selling the customer in a beautiful and often luxurious salesroom, he condemns him and the car to an inadequate, poorly organized service-system for all the rest of his associations with the company.

Fortunately, there are encouraging signs of a proper appreciation of service values; as shown by the increasing number of splendid plants being constructed solely for service purposes in the larger centers of distribution. The responsibility for good service is a mutual one of the manufacturer and the dealer and, for their lasting success, it means the closest kind of cooperation in all that pertains to improving service and increasing sales. For, after all, the two problems are one.

RESERVE RESOURCES

THE strength of every business situation is in reserve resources. If everybody was careful to have ample resources in reserve there would be no crises. Our Federal Reserve System was planned to have ample reserve resources, but all banks came out of the war period very much extended. They did not have the resources in reserve that they were planned to have, and that with a proper regard for security they should have. The Joint Commission of Agricultural Inquiry expresses the opinion that steps should have been taken to check inflation earlier than was done, and this opinion I am bound to say is well supported in the judgment of the banking community.

If I wanted to state in the fewest possible words an explanation of the agricultural distress of the last two years, I should put it in three words, Too much borrowing. The wholesome fear of debt that was prevalent when some of us were young has been largely dissipated by the rising prices of the last 25 years. Men have been led to believe that the way to get ahead is by the use of borrowed money, and that the smaller the margins on which they operate the more rapid their progress will be. The truth is that the number of men able to use borrowed money advantageously always has been comparatively small.

I do not wish to be understood as representing farmers as a class as more imprudent or reckless than other people, including business men generally. They had plenty of good company, both in borrowing and in losing. They did just what most business men did; and the combined effect of this general policy of inflation was to overdo the use of credit, create an abnormal price-level and bring about a disastrous reaction. It is pertinent, however, to point out at this time, when relief for the farmer is proposed through various plans for providing him with more credit, that the chief factor in the plight in which he is now struggling has been too much credit. I do not know of any branch of agriculture in which at this time production is deficient for the want of credit. I think there is more agitation for means of restricting production than for means of increasing it. It is probable that the class of farmers who are in deepest distress now would be in still deeper distress if prices went lower as a result of placing increased facilities for production at the command of the more efficient class of farmers. It has been stated in a leading farm journal that

> In spite of the temporarily bad situation, so far as the average Iowa farmer is concerned, there are thousands of farmers, who own their own farms and who saved their money during the war, who are better off than they have ever been.

The class of farmer referred to belongs to the class of men in every line of business, who are the leaders and price-makers, and make conditions difficult for competitors.—George E. Roberts before Academy of Political Science.

The Connection of the Research Committee with Fuel Research[1]

By H. M. CRANE[2]

I SPEAK about the connection of the Research Committee with fuel research in particular because, while there have been other activities of the Research Committee, we recognize that its work for 1922 will have to stand or fall on its fuel activities. The Research Committee was a natural successor to the former Fuel Committee which I first became associated with about 3 years ago. At that time the position of the automotive industry in regard to fuel was very much the same as that of the turkey about 3 days before Thanksgiving; it thought the axe was going to fall, but it did not know just when or where it would hit, in regard to the kind of fuel it would be asked to use.

It was plain that we did not know nearly enough about the fuel problem, about how fuel was made or how it could be or should be made; or, from our own side of the question, how it could best be used. It seemed to me then and to the other members of the Fuel Committee that the obvious thing to do was to get nearer to the technical men in the oil industry, for one thing, and also that all of the technical men in our own industry should draw more closely together on the particular question of design, which looked at that time as if it might be the limiting factor in the possible use of automobiles. There seemed to be an opinion then that possibly it would be a question of how much fuel we could get, rather than of how many people we could get to buy cars. Beginning at that time, we made a consistent effort to come closer to the technical people in the oil industry and at the same time, I thought that it would be a good thing to proclaim a little more loudly some of our own difficulties, with the idea that this could not fail to help in improving the general situation.

I will pass over the intervening 2 years and come to a point about 1 year ago. We had made a very surprising advance, I think, at that time. We had our own Research Committee, while the petroleum industry had organized, in the American Petroleum Institute, a technical division under the leadership of Dr. Van H. Manning. We were in such close harmony that it became possible to proceed with a joint research on the fuel question. There is nothing like a joint research of this kind to clarify the ideas of both parties to the research. The actual working together in attempting to arrive at a just conclusion on any problem goes a long way toward making the problem itself clearer, and toward making it more certain that a just conclusion will be obtained.

Financial Support and Program

Less than a year ago we were able to get substantial support from the National Automobile Chamber of Commerce in a financial way, and from the American Petroleum Institute, for a joint research on the fuel problem. There was practically no hesitation in the minds of either your Committee or that of the American Petroleum Institute in putting the expenditure of the first of this money into the hands of the Bureau of Standards, since the Bureau of Standards had, through W. S. James, presented a program covering a method of investigating the use of automobile fuel in a number of different cars, which appeared to all of us to offer possibilities of some very substantial and useful information.

The first test under this joint proceeding was carried out in the summer of 1922 by the Bureau of Standards, and a report of the results is already in your hands. At the same time a number of companies in the Detroit district and in other places offered their cooperation in making service tests on fuel similar to those being tested at the Bureau of Standards. The paper presented by V. H. Gottschalk[3] is a result of those tests. As can be seen, these tests covered a wide range of cars under a very considerable range of operating conditions, it being understood, however, that practically all of them were carried out in summer weather.

It has seemed to me that there are two phases to this problem. One of these is in relation to the kind of fuel we would like to get, if we can. I have believed from the start that we would never get the best solution of the problem from an economical point of view, until we came to a realization of the best fuel for the purpose. From an economical point of view, however, I have recognized, and all of us have recognized, that it probably is impossible to get anything approaching what we now consider to be the absolutely best fuel. We believe that possibly from 3 to 5 times the quantity of the very best fuel is available in the form of a fuel which differs from the very best in such a small amount as to be possibly unrecognizable in the hands of many drivers. Therefore, the second phase of the problem involves what is the biggest departure from the theoretically best fuel that can be handled successfully in the present-day automobile.

The Bureau of Standards tests were directed along those lines by taking samples of cars representing something like 75 per cent of the total number of cars in use in this Country, and operating them under supposedly service conditions. The chief difference between the Bureau of Standards' tests and those carried out by the companies lies, I think, in the fact that the companies' tests represented a somewhat more advanced product than was represented in the Bureau tests; that is, many of the cars used by the companies were cars of uptodate design. The result of these tests, as a whole, from an economical point of view, was certainly satisfactory. It indicated that in warm weather, in any event, purely from a mileage point of view, a fuel considerably worse than what is now being supplied will produce mileage almost in proportion to the quantity consumed. I think that a careful reading of the report of the company tests will indicate that the satisfaction with the heavier fuel was the same as with the lighter, but we have always sacrificed something to be able to use cars at all,

[1] Annual report of the Research Committee.
[2] M.S.A.E.—Consulting engineer, New York City.
[3] See THE JOURNAL, January, 1923, p. 3.

and we shall have to sacrifice something in our actual use of cars to allow of our getting the fuel to use them; there is no question about that.

To check-up on the result of the tests at the Bureau of Standards, a friend of mine ran a short test on a car that has a planetary gearset and a thermosyphon water-circulation. This car is fitted with a carbureter presenting about as good metering characteristics as are possible at present. It was first tested for acceleration, and then for road mileage, with two different grades of fuel. These two different grades tested 60 and 69 deg. Baumé respectively, one of them being the standard fuel in the district and the other a higher-test fuel which is also on sale regularly in the same district.

It is believed that both these figures are slightly high; but they are relative because the same hydrometer was used in both cases. Two tests were made in each case, one cold and one hot. With the heavier fuel, the water temperature was 87 deg. cent. (188.6 deg. fahr.) hot and 65 deg. cent. (149 deg. fahr.) cold, and with the lighter fuel about 80 deg. cent. (176 deg. fahr.) hot and 55 deg. cent. (131 deg. fahr.) cold. The most rapid acceleration obtained was from 10 to 20 m.p.h. in 6 sec. with a No. 4 setting on the lighter fuel with the cold engine. As against this, the time for the fastest acceleration with the heavier fuel was 7 sec., but it was obtained only with a hot engine, and with a setting 1 deg. richer on the carbureter. On the other hand, with the hot engine, the fastest acceleration with the volatile fuel was 10 to 20 m.p.h. in 6½ sec. I bring this last point out because it shows pretty clearly the reason why many of these service tests indicate so little difference between the different grades of fuel. We do not take advantage in the service tests of the ability to run colder with the fuel of higher volatility and thereby obtain greater power from the same engine. This is clearly brought out in this test, because the difference is very marked between the maximum acceleration possible with the high-test fuel when the engine is cold and the acceleration with the engine hot.

Road Tests

A number of road tests were made with different carbureter settings, again using the different fuels and the two temperatures. The greatest mileage obtained on 1 pint of fuel at an average speed of about 18 m.p.h., on a rolling road surface with grades up to 4 per cent, was at the rate of 32.8 miles per gal., using the lighter fuel, which is very far beyond the average mileage shown in the Bureau of Standards tests. The highest rate obtained with the heavy fuel was 28.8 miles per gal. On the other hand, with the carbureter setting of 5, with the engine hot in both cases, the mileage per gallon was exactly the same, 19.2. The two other figures obtained indicate clearly that the average owner, if at all careless of carbureter setting, might easily get worse mileage with the more volatile fuel.

I am not presenting those figures as an argument for using 69 deg. gasoline. I would rather use it myself, I will admit. But I think the figures indicate somewhat why the results that were obtained last summer were obtained, and also that they emphasize the possibility that the general public, not the skilled drivers, will do about as well with the heavier fuels as with the lighter one, so far as road mileage is concerned. That, after all, is part of our investigation. I still believe that, in a car especially adapted for the lighter fuel, we can show substantially better results with the light fuel than we can with the heavier one; but, in a car adapted for the heavier fuel, the light fuel will show no great road-mileage advantage, up to a fuel heavier than we have today.

I regret to say that, in our own industry, there is a trend in engine design which will be hard to satisfy with heavier-grade fuels. That is an attempt to obtain high engine-power at high engine-speeds. This can be done only by the use of large carbureters with low depression, by large manifolds and valve-ports, and all of these things are the worst possible adjuncts to a proper handling of a fuel of low volatility. Every airplane participating in the 1922 Pulitzer Race used, I believe, aviation gasoline mixed with 50 per cent of benzol. They did not consider the cost of the fuel at all; it was a question of performance, and they used what their experience showed would give them the best performance. The reason, in their case, why the performance is the best is that they operate with a cold engine, one as cold as they can get it, for the obvious reasons of an improved volumetric efficiency and a reduced tendency to detonate. With the large manifolds and large fixed-opening carbureters employed, a heavier fuel to obtain maximum power at high speed simply will not control. If the engine throttle is down and an attempt is made to open it up suddenly, the engine just dies; it will not operate. I say that I regret to see that our own industry seems to be pointing a little toward a type of design that does not go satisfactorily with the type of fuel that we probably will have to use. At the same time, I wish to call attention to the fact that the automotive engineer is being forced to design engines of less overall operating flexibility to cope satisfactorily with less volatile fuel. Fortunately, the great majority of both truck and passenger-car users do not require, in regular service, any such wide range of flexibility as can be obtained with fuel more volatile than is being supplied today.

Continuation of Tests

I said earlier in this talk that I consider that we have not finished the investigation of fuels. We have made a summer test, and know something of the probable result of summer operation. I think that we should also have a cold-weather test to complete the cycle, where conditions are possibly fairly extreme. I do not ask for extreme weather-conditions simply to try to put over a point of view on the oil people. I think that we can be trusted to assess fairly the amount of cold-weather and hot-weather running that has to be considered; but we all know that it is often wise to make an extreme test in making an experiment to get an idea of the general trend of things; we can go from an extreme to an intermediate test after we have established a general trend, while we may cloud the situation entirely by making an intermediate test with minor variations only.

For instance, we might start with a gasoline of 300-deg. end-point and raise the end-point 10 deg. at a time, allowing a driver to test first one and then the other. I think we might get him up to a gasoline with a 500-deg. end-point by such steps, and at every step challenge him to tell which was which. It is obvious that, even if he could not tell a difference in the operation at each of the intermediate steps, that would not mean that he could not easily tell the difference between a gasoline of 300-deg. and one of 500-deg. end-point; we would simply have been making the steps too short to cover the inaccuracies of observation or of measurement. That is the way I feel about the cold-weather test. I would like to see it made under such severe conditions that it

will show something very definite beyond the possibility of argument as to what it means. I think I can say for the automotive industry that it will be glad to assess the test on its value as a test, including the temperature conditions, and be willing to reason from that back to what the normal average temperature conditions are.

Fuel Volatility

In relation to fuel volatility, we have heard considerable talk about crankcase-oil dilution. I look on crankcase-oil dilution to a considerable extent as a ready means of determining what the fuel volatility is doing in the engine. In other words, it is one of the few things that changes extremely with moderate changes in volatility. In the Bureau of Standards tests and those at Detroit, this was the one thing that showed-up plainly on all the cars as a variant with the use of the different fuels involved. From that point of view it is an interesting test; but, as a member of the automotive industry, I think that, from its actual effect on the operation of the engine, we are not ready to go to the mat with the oil people on the basis that a certain percentage of crankcase-oil dilution is a certain proof that a type of fuel is inadmissible. I would find it very hard to try to prove that mixing 10 per cent of kerosene with the oil generally used in any of our engines would upset the lubricating system or wear the engine out prematurely.

Judging from data in my possession, I think we can not blame all the wear that takes place in automobile engines on crankcase-oil dilution. The data refer to a car that has been, I think, about 90,000 miles; the owner says 150,000 miles. It was examined personally by me 3 years ago and showed no measurable wear in the pistons, cylinders or rings, and not sufficient wear in the main or the crankpin bearings to justify any work. The owner did not ask about getting a new carbureter or a new manifold, or whether he ought not to stop the oil-pumping, or whether he needed new rings or pistons; he feared that, possibly, the old machine was getting tired-out and ought to be put on the shelf. The data simply show that a car will operate for long periods on standard every-day gasoline, undoubtedly with a certain proportion of crankcase-oil dilution, without wearing-out.

As I said previously, we may be able to use crankcase-oil dilution as a ready means of measuring the probable general effect of too heavy fuel; and, for that purpose, I think it has its advantages. But I think that we cannot safely take the ground that it upsets the lubrication of the job in such a way as to make the use of a fuel causing a certain percentage of dilution out of the question or even economically impossible.

Quoting from Mr. Gottschalk's paper, under the head of Drivers' Comments,[4] I have been told many times that nobody can tell the difference in the service obtained from fuel by the degree of satisfaction of the driver; I do not mean as to road mileage, but whether the drivers like it. The quotation is:

> Three of the cooperating companies inserted their drivers' comments on the relative performance of their cars with the separate fuels. The comments of these 25 drivers indicated that greater volatility of the fuel leads to a greater ease and satisfaction in driving, while a high-end-point gasoline, such as *D*, induces "spark-knock," slowness in warming-up, sluggish acceleration and other difficulties. One driver considered all four fuels about the same, and in two other instances only did the driver's order of preference not conform to the order of volatility, *A*, *B*, *C*, *D*.

I would like to have you look at the distillation curves of these four fuels, shown in Fig. 1 of the paper,[5] see how close they are together and then read that last sentence again. Practically 22 drivers, out of 25, were able to place these four fuels in their order of volatility by operating the car; and we are informed that the drivers were not told what fuel they were using. Also bear in mind that this test was run in summer.

In closing, I want to express the thanks of the Research Committee and of the Society to the companies that cooperated in this work: To the Buick Motor Co., the International Motor Co., the Ford Motor Co., the Packard Motor Car Co., Dodge Bros., the Studebaker Corporation of America, the Hupp Motor Car Corporation, the Willys-Overland Co. and the Stromberg Motor Devices Co.; also to the staff of the Bureau of Standards; and finally, to the American Petroleum Institute, which, as an organization, has worked with us. Further, we thank members of the American Petroleum Institute who supplied fuels for the tests; a great amount of special fuel was required. They furnished technical assistance and men to assist in the running of the tests also.

[4] See The Journal, January, 1923, p. 7.
[5] See The Journal, January, 1923, p. 3.

DETERMINING THE MAGNETIC PROPERTIES OF SHORT BARS

THE growing interest among engineers and designers in the correlation of the magnetic and other physical properties of iron and steel has given impetus to the study and development of methods for making the necessary magnetic measurements. Many materials of an experimental composition or of extreme purity are available only in limited quantities, and the ability to obtain magnetic measurements on small samples would be of decided advantage both from the point of view of economy of material and because of the ease of the machining and heat-treatment.

The direct determination of the magnetic properties of small samples with any degree of accuracy is a difficult matter, but the Bureau of Standards has recently developed an apparatus that is capable of measuring the magnetic properties of such a sample with a satisfactory degree of precision. The method involves the comparison of a sample of the material to be tested, which is in the form of a cylindrical bar 6 mm. (0.23622 in.) in diameter and 10 cm. (3.937 in.) long, with a reference bar, the apparent magnetic properties of which have been determined through calibration by standard bars having accurately known properties. This method is capable of giving results within 5 per cent for most materials. As the accuracy depends, to some extent, upon the degree with which the properties of the test bar agree with those of the standard bar used for the calibration, the range of materials that can be tested with satisfactory accuracy depends upon the range of properties covered by the series of standard bars.

Over-Loading of Motor Trucks[1]

By DAVID C. FENNER[2]

EFFECTIVE regulation can be accomplished only after a careful investigation and determination of the direction and amount of deviation from standards of normal practice. When we attempt to determine the facts regarding the loading of motor trucks we are handicapped by the lack of a standard that can be used as a practical basis of comparison. A motor truck is a carrying tool but not necessarily a measuring tool. It should be placed in the same general classification with the shovel and the wheelbarrow and not with the quart and peck measure and the bushel basket.

The over-loading of motor trucks is due in part to the improper basis of rating and classifying the motor-truck chassis in terms of the builder's rated pay-load capacity. The user soon learns that this rating really does not mean anything. He purchases a motor-truck chassis, attaches a body that may or may not fit either the chassis or the commodity to be carried, and then loads the truck to suit himself. It would seem, indeed, that the motor-truck body is the real measure of capacity that determines the size of the chassis that must be used to carry it, loaded with the commodity to be hauled.

In the sale of motor transportation, the successful salesman conducts a careful survey, the results of which convince the customer that a certain type, size, capacity and weight of body are necessary to fill his transportation requirements. Then he is in a position to sell the customer the proper type and size of chassis to carry this body loaded to capacity with the particular commodity that it is purchased to haul. The large number of misfit motor-trucks on the road today are the best possible examples of the other method of selling the motor-truck chassis first and allowing the customer to put on the chassis any body and to load it in any way.

Each chassis, when it leaves the builder's plant, has a definite rated capacity for both the body weight and the weight of the load. If a particularly heavy body is mounted, or various forms of auxiliary power devices mounted in addition to the body exceed the body weight-allowance determined by the chassis builder, the pay-load capacity must be reduced accordingly. In the case of dump-bodies with hoists and transmission power-take-off, power-driven winches, pumps, air-compressors and various other forms of auxiliary power devices, this excess weight is considerable, and in many cases over-loading would be reduced if a larger-capacity chassis were used.

Manufacturers have suggested that State motor-vehicle commissioners should refuse to license any truck that is not equipped with a manufacturer's caution-plate properly specifying the actual weight of the chassis and the body and the load capacity. They are now proposing to go a step further and indicate on this plate the maximum allowable gross-load for the front axle and for the rear axle, the maximum allowable speed and the distance in which the vehicle when loaded to capacity can be stopped with each set of brakes operated independently with the vehicle running at the stated maximum speed on a hard, dry, level roadway. The information on this caution-plate will give the owner the data he needs for painting the weight and carrying capacity on the sides of the vehicle to comply with the State law. It will also enable the local enforcement officer to check the distribution of weight between the axles, the maximum speed and the condition of the braking system. A similar plate for use on home-made trucks can be issued by the State motor-vehicle department. The information contained on this plate will prevent the operation of improper trucks and force the proper operation of good trucks. It will put the penalty for poorly adjusted brakes and steering connections directly up to the operator, where it belongs.

The man who over-loads to take advantage of the "overload capacity" offered by some truck salesmen encounters the general law of averages. In the end he gets just about what he pays for and no more. Invariably, the owner who follows this practice keeps no operating costs that are worthy of the name. The man who persists in wilful over-loading in the face of all the facts is a menace to public safety and should be refused permanently either a vehicle or an operator's license. He has forfeited his right to use of the highway. A few less of his kind on the highway will be a distinct benefit to highway transportation.

Joseph F. Whelan, one of the most progressive and successful professional truck-operators in New York City, says

> With regard to the perpetual statement that the regulation of loads to the builder's rated capacity would put the truckmen out of business, I would say that this is not so. Such regulation would help them materially. If it did nothing else, it would bring to a halt the activities of the irresponsible operators who have no regard for either their mortgaged equipment or their legitimate competitors.
>
> Truck-load regulation would mean that prices could be standardized and much equipment that is now idle operated at a fair profit, because additional trucks would be needed to carry the freight formerly piled haphazardly upon two or three long-suffering and much-abused vehicles.

Investigations conducted in some of the States show that the light and medium-capacity vehicles are over-loaded to a greater extent and in greater numbers than the heavy-capacity vehicle. This indicates the importance of restricting loads per inch width of tire per wheel and per axle. We must recognize the four classes of tire; pneumatic, cushion, solid-rubber and metal; in regulating speed and the determination of license-fees according to wheel-load. We must restrict the minimum thickness of solid and cushion tires when measured between the tire flange and a flat metal surface on which the wheel stands. We must also take into account the condition of the tire.

The safety of the public, the preservation of the highway, the economy of vehicle operation, the status of the operator and the successful and economic development of highway transportation all demand that the practice of over-loading should be discouraged, forbidden, prohibited and stamped out completely.

Put it up to your local motor-truck association to stop the practice of over-loading or take the consequences of a concerted action of the local automobile-owners' association and the local chamber of commerce to report to the enforcement officers every truck that shows the slightest evidence of being loaded beyond its capacity.

Take all the satisfaction out of over-loading. Then the man who has been over-loading just to beat the game will quit and the chap who is really forced by circumstances to haul more than the rated capacity of his present vehicle will buy a larger vehicle or a trailer. With a semi-trailer he can double the capacity of his present vehicle; by distributing the gross load over six wheels he can keep within the wheel weight-restrictions of the State law and the builder's rated capacity of the truck and help to preserve the safety of the public and the best interests of highway transportation.

The motor-vehicle industry stands solidly behind the rigid enforcement of the provisions of the Proposed Uniform Vehicle Law and the existing State laws. It condemns over-loading and over-speeding unreservedly, and will cooperate actively in every movement to regulate loads and speeds of motor trucks on the highway.

[1] Presented at a joint session of north central division of the National Highway Traffic Association and the Michigan State Good Roads Association, at Grand Rapids, Mich.

[2] Manager of the public works department, International Motor Co., New York City.

Society's Research Sheds New Light on Fuel Problem

By V. H. GOTTSCHALK[1]

ANNUAL MEETING PAPER

ADDITIONAL data on another group of four cars were received too late for inclusion in this paper when it was printed in THE JOURNAL. The data are now appended in supplementary form, together with the discussion that followed the presentation of the paper. For the convenience of the members, a brief abstract of the paper precedes the discussion, with a reference to the issue of THE JOURNAL in which the paper appeared, so that members who desire to refer to the complete text as originally printed, and the illustrations that appeared in connection therewith, can do so with a minimum amount of effort.

ABSTRACT

THE author describes a series of road service-tests, made of stock cars driven by their usual drivers when using fuel of specified grades, to determine the effect of any changes in the fuel volatility on the gasoline mileage for the respective make of car as part of a general research program undertaken jointly by the automotive and the petroleum industries. The object was to determine the best fuel as regards volatility, from the general economic standpoint, and what grade of fuel will afford the maximum car mileage per barrel of crude oil consumed in its production.

Factors influencing the selection of cars used are enumerated and the fuels tested are discussed, together with general comment and a description of the test procedure. The results are tabulated and commented upon at some length, inclusive of descriptions of the methods. A summary of the results is presented in the form of conclusions that are stated in four specific divisions. The value of statistical research is illustrated by the results obtained. [Printed in the January, 1923, issue of THE JOURNAL.]

SUPPLEMENTARY DATA

The additional data received apply to another group of four cars. The figures for gasoline and oil mileages obtained with these four cars are given in Table 5, which supplements Table 2 of the paper and corrects the averages to comprise the results of all 59 cars. This report of the tenth and last cooperating company brings the total mileage of the test up to 61,114 and changes the average of the 223 test-periods to 274 miles each. To include the new figures, Table 1 of the paper should be modified so that lines 2 to 8 of the second column will read 63, 74, 42, 17, 4, 1 and 5.

TABLE 5—GASOLINE AND APPARENT LUBRICATING OIL MILEAGES

No. of Car	Miles per Gallon of Gasoline				Apparent Miles per Gallon of Lubricating Oil			
	A	*B*	*C*	*D*	*A*	*B*	*C*	*D*
48—1	17.61	17.77	19.16	18.92	333	426	587	734
53—1	19.57	19.84	17.37	18.51	342	662	817	1,150
54—1	16.66	21.66	20.80	22.08	708	890	791	1,458
54—2	20.94	21.92	20.52	18.11	545	629	599	(a)
Average for 59 Cars...	15.09	15.33	15.04	15.05	631	755	792	927

(a) More oil at the end of the run than at the start.

The new figures change the oil mileages less than 1 per cent. The gasoline mileages show a slightly larger maximum-difference, 1.9 per cent instead of 1.6 per cent as previously obtained, and they are higher than for the original 55 cars. The car numbers given in the first column of Table 5 have been chosen to indicate the position of the additional four cars as regards the increasing order of Grade-*B* gasoline mileages. It will be noticed that they come at the bottom of the Table 2 of the paper and make a very welcome increase in the number of the high-mileage figures. The four new points to be added to each one of the three graphs of Fig. 4 of the paper will be found to lessen the degree of abnormality in the appearance of the high-mileage ends of the graphs.

TABLE 6—TON-MILES PER GALLON OF GASOLINE BASED ON A LOAD OF TWO PASSENGERS OF 150 LB. EACH

Group	*A*	*B*	*C*	*D*	Group Averages *A*	*B*	*C*	*D*	Expressed in Terms of *B* as 100 per cent *A*	*C*	*D*
13	22.9	23.9	22.4	19.8	...	...	...	...	...	...	...
	18.2	23.6	22.8	24.1	...	...	...	...	...	...	...
	19.3	19.5	21.9	20.7	...	...	...	...	...	...	...
	21.4	21.6	19.0	20.3	20.5	22.2	21.3	21.2	92.4	96.1	95.5
			Averages for 13 Groups		22.6	23.2	22.7	22.6	...	...	...
						Means for 13 groups			97.8	98.1	97.9
						Mean deviation of the mean			1.6	2.1	2.4
						Mean deviation of single observation			5.8	7.7	8.6

Table 6 gives the data for these four cars as recalculated to show the number of ton-miles per gallon of gasoline. Table 6 is a new group. No. 13 is to be added to Table 3 of the paper. This is of questionable propriety because, besides some minor variations from the general scheme followed with the other groups, group No. 13 was tested in the period from Nov. 23 to Dec. 3, 1922, while the other 12 groups were run in the months of June and July, 1922. Nevertheless, we have calculated the averages of the group averages and the means, together with the deviations, and have included these numbers in Table 6 for comparison with the corresponding numbers in Table 3 of the paper.

Other additional data that have been received since the report of the company tests went to press is a fourth

[1] M.S.A.E.—Research engineer, Society of Automotive Engineers, Inc., New York City.

TABLE 7—CRANKCASE-OIL DILUTION FOR SET 4, GROUP 9[b]

Fuel	A		B		C		D	
	Percentage Distilled Off[3]	Viscosity[4]	Percentage Distilled Off[3]	Viscosity[4]	Percentage Distilled Off[3]	Viscosity[4]	Percentage Distilled Off[3]	Viscosity[4]
	6.1	195	9.5	169	11.0	156	....	....
	4.0	230	4.5	215	8.0	155	11.0	145
	7.0	194	11.0	156	8.0	176	9.0	172
	5.0	217	4.5	212	5.0	194	7.8	193
	3.0	233	7.0	174	11.5	154	6.5	190
	....	....	....	....	20.5	97	....	....
Group Average	5.0	....	7.3	....	10.7	....	8.6	....
Average of the Groups Recalculated to Percentage Dilution	5.3	....	7.9	....	11.6	....	9.4	....

Original Oil

Specific Gravity	0.905
Viscosity at 100 deg. fahr., Saybolt sec.	303
Flash-Point, deg. fahr.	430
Fire-Point, deg. fahr.	495

[b] Table 4 of the paper should be corrected so that the Group Numbers in column 1 will read 10, 11 12, 1, 2, 3, 7 reading from above downward.
[3] Dilution figures are given as percentage of gasoline distilled from the crankcase oil.
[4] Saybolt viscosity at 100 deg. fahr.

set of crankcase-oil dilutions belonging to this series and determined by the Bureau of Standards. These figures are given in Table 7 as a matter of record.

In conclusion, I take this opportunity to state that I am responsible for the calculations involved in the compilation of the data contained in the company reports, but that to Dr. H. C. Dickinson, research manager of the Society, belongs full credit for the conception of the idea and for the working plan of the statistical method as applied so successfully to the fuel research.

THE DISCUSSION

V. H. GOTTSCHALK:—The work reported in the paper is just one part of the cooperative fuel research. R. E. Carlson gives an outline of what we are trying to do in his paper on Economic Motor-Fuel Volatility.[2] We used the same fuel that Mr. Carlson dealt with, Grades *A*, *B*, *C* and *D*. In our case it was manufactured by a Western refinery, but the specifications were the same. If Fig. 1 of my paper is compared with the corresponding figure that Mr. Carlson gave, it will be seen that the curves are about the same. Our 10-per cent point was not so accurate as that which the Bureau of Standards had, but the end-points, or the spreads between the end-points, are about the same, I think. They are supposed to represent the same fuel and represent probably about what can be done in a gasoline refinery with reference to coming-up to specifications.

DR. VAN H. MANNING:—I am looking at the oil industry and at the automotive industry and I am watching the results of these investigations in an unselfish attitude of mind. Some difficulties to be encountered occurred to me when Mr. Gottschalk referred to the running of these tests by the average driver. Assuming that there are two drivers for every car in the United States, there are 24,000,000 people that you must educate to drive a car. I have been in educational campaigns for years, and I know how difficult it is to put these things over. I feel sure that, when these tests are finally concluded, you automotive engineers will get a satisfactory answer, an answer given by both industries, the two biggest in the world.

I want to take this opportunity of extending, on behalf of the oil industry, our appreciation of the splendid cooperation which we have had from the President, the General Manager and the Research Manager of the Society of Automotive Engineers, and from the National Automobile Chamber of Commerce.

[2] See THE JOURNAL, February, 1923, p. 139.

Vol. XII February, 1923 No. 2

Cheaper Closed-Body Construction

By GEORGE J. MERCER[1]

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS

THE author quotes statistics relating to the proportion of closed to open bodies and outlines the changes that have taken place in body construction in recent years. He sketches the advances that have been made and states that the question to be answered now relates to what all this improvement in manufacturing methods has accomplished toward reducing the price of a closed-car body to the consumer. He compares the percentage of public benefit in 1922 with that of 1914, excluding the period of inflated prices immediately following the war, and states that it is 10 to 15 per cent, but says also that this is an unfair comparison because of the excessive increases in the cost of labor, lumber, sheet steel and trimming cloth.

An unconventional type of body, covered entirely with fabric over a foundation of wire-mesh and buckram fastened to the conventional wood-framing, is illustrated and described in detail, together with a statement of its advantages.

IN the news items of the trade journals and the automotive notes in the daily papers, continual statement is made that some one or other of the car builders is behind in the delivery of closed-body models. There are more than 1,500,000 closed-body cars in use in this Country at present, or 16 per cent of the total registration. In 1916 the proportion of open to closed cars was 1 per cent; in 1918, the output of closed bodies was 71,000; in 1919, it was 197,000, or 10 per cent; in 1921, it was 335,000, or 20 per cent, and the estimated output for 1922 is 635,000.

The increase in the use of the closed-body car justifies the statement that the closed body is superseding the open one as fast as reduced prices and manufacturing facilities permit. The open model will have its place, but will be more of the semi-racing or sport type and some one of the closed models will have to be featured in advertising, as the open body formerly was, to attract sales by its special value for the price. The problem is, how can a closed body be made much cheaper and yet retain approximately the present standard in appearance and service quality?

CHANGES IN BODY CONSTRUCTION

To arrive at a point of reasoning for the future, it will be well to review the changes that have occurred in body construction. Commencing with the all-wood body similar to that of a carriage, improvement was made by the substitution of sheet aluminum for the panels. During the time that aluminum was exclusively used, some companies made the panels of cast aluminum; the Pierce-Arrow Co. made all its bodies in this way for years. The next forward step was the use of sheet-steel panels. This was accomplished only after strenuous efforts, as neither the steel then available nor the machines for pressing and stamping were suitable for body requirements. The improvements since that time have been along the line of improved and more extensive stamping and drawing operations and, as a consequence, the labor of assembling has been lessened and some operations have been eliminated.

[1] M.S.A.E.—Consulting engineer, Detroit.

The all-steel body made by the Edward G. Budd Mfg. Co. for Dodge Bros., and used by the latter for several years, is a further advance from the conventional wood-frame and steel-panel construction. It has been limited, until recently, to the open types. Its advantage is not so much any strength that it has over that of the combination body, because the latter is all-sufficient for service, but that the body when assembled can have the bake-enameled, whereas the wood frame of the combination body will not withstand the high temperature necessary for baking.

The advantage of the enamel finish is easily established in view of the fact that practically all cars have mud-guards, splashers and, wherever possible, radiators and engine hoods so finished. The advantage of applying this finish to the entire surface of the body is very great. The feature of a durable surface is but one of the merits; another is the saving of time. The Dodge body is finished complete in 1 day. The cheapest painting job will take 5 days, while a paint operation that will stand-up for a season will take 12 days. Because the heavy initial-cost to install this form of manufacturing necessitates the continuance of one model for a long period without changes to absorb this cost, and also because the baking process is limited to black, this method is confined to companies who make a standardized product in large quantities.

In addition to the distinct manufacturing changes already enumerated, there have been other changes that have had an effect in reducing manufacturing costs. For instance, the bodies are smaller; formerly, nearly all bodies were seven-passenger, now the majority are five or four-passenger. The design of the body is simpler, the aim being to economize in material and labor by having straighter lines, less extreme radii in the rounded corners and curves, a less number of moldings, simpler door-hinges, duplicate glass-sizes, simpler trimming design, fabric roofs in place of solid panels and improved painting methods in which, by the use of the spray and drying ovens, the time of painting has been reduced from 4 weeks to 12 days. The conveyor has been adapted for body use in all departments, and has become as necessary in this work as in chassis assembling.

ADVANCE TOWARD SIMPLIFIED CONSTRUCTION

At present, the advance toward a simplified construction that will reduce manufacturing costs is to make the body complete in sections and to ship it in knocked-down shape. This method, which is still in a partially experimental stage, will develop rapidly.

The question we want answered now is, What has all this improvement in manufacturing actually amounted to in reducing the price of the body to the user? Leaving out the post-war period of inflated prices, and comparing 1922 with 1914, the public benefits to the extent of a flat average of from 10 to 15 per cent; but this is not a just comparison because labor is paid 100 per cent more, and lumber costs 77 per cent more, sheet steel 43 per cent more and trimming cloth 80 per cent more. These

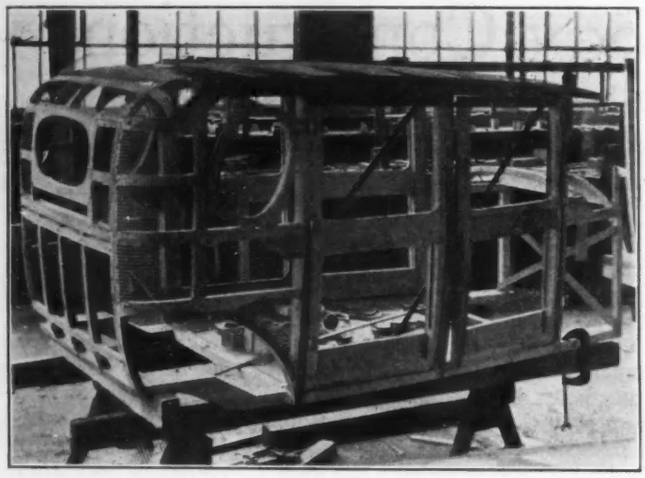


FIG. 1—FRAMEWORK OF THE BODY AFTER THE NO. 19 WIRE MESH HAS BEEN APPLIED

items show what the body builder is up against; what his problem has been, and is, of how to market an article for less money and yet pay more for material and labor.

One other item is to be considered: Style or design. The appearance of the body is so important that car-sales are made or lost in accord with this feature, provided the other parts of the car are equal in merit. Consequently, this elemental part of the body, that appeals to the artistic sense of the purchaser, bulks large with the selling organization and is a determining factor in production.

To sum up, closed bodies must be produced more cheaply, and have a sufficient amount of style to attract favorable attention, minimize sales resistance and make commensurate advertising expense worthwhile. In addition, they must be of light weight; recent data show that 71 per cent of passenger-car sales are confined to the medium and low-priced small-cars. In Europe very light small cars, designed to minimize upkeep and operating expenses, are being made. Since 1916, although the Ford Motor Co. has increased its output, its proportion of the total volume of business in the less-than-$1,000 class has constantly decreased.

AN UNCONVENTIONAL TYPE OF BODY

At the time I was asked to write this paper, I had in mind the sectional-finished body with its possibilities of finishing complete in easily handled parcels, by this method, saving in shop space and allowing cheaper transportation expenses and the speeding up in production. But I had thought of this only as a metal-panel body, until K. L. Childs, of the Standard Textile Products Co., gave our firm an order to make a body to demonstrate the practicability of covering a body entirely with fabric over a foundation of wire and buckram fastened to the conventional wood-framing.

FIG. 2—THE WIRE MESH IS COVERED WITH A LAYER OF COTTON WADDING AFTER WHICH BUCKRAM IS APPLIED

This idea is not new in its entirety. Fabric has been used for body covering by shellacing the fabric over the steel panels. Reports of its wearing qualities have been uniformly satisfactory. We are familiar with the California top; and this, too, has given uniform satisfaction when a good quality of fabric material has been used. The service that the fabric top has given is generally known; so, there is a fair background of experience upon which to base one's judgment as to the practicability of making a real fabric-covered body, eliminating the steel under-panels and using a foundation that is cheaper, lighter and more easily and quickly applied, yet having sufficient rigidity to retain the shape when molded.

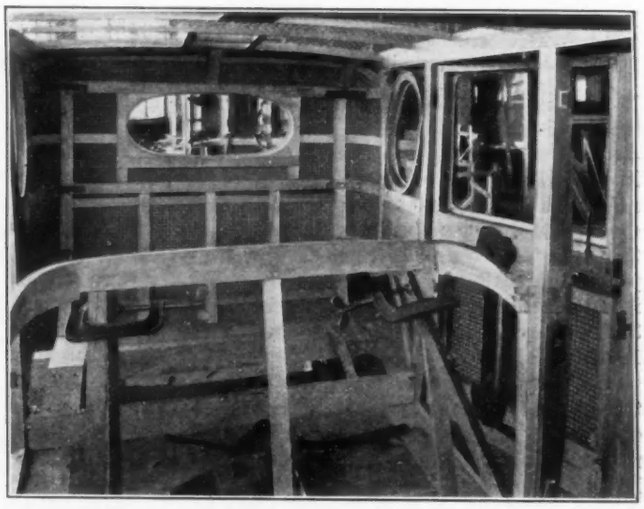


FIG. 3—AN INTERIOR VIEW OF THE BODY AFTER THE BUCKRAM HAS BEEN PLACED

The illustrations presented show the progressive steps in making this sample experimental body. They are to be considered as indicative of experimental or research work only. The application of this principle to the conventionally designed body, whereby we plan to make it cheaper and lighter, is now under way, and we expect to be as successful as we have been with this sample of expensively designed coach-work.

Fig. 1 shows the application of the wire to the framework. This is a No. 19 gage, 2 meshes to the inch, and fastened with staples. Fig. 2 shows the buckram fastened over the wire. One layer of cotton wadding is placed between the wire and the buckram and the framework is double-rabbeted, one rabbet being for the wire; the one for the buckram is wider, so as to have it cross the joint and be nailed beyond the wire edge. Fig. 3 is a view of the interior of the body, and Fig. 4 shows the body with moldings tried-on and ready for the fabric covering, which is shown applied in Fig. 5. It will be noted that the door and window openings have rounded corners; this is necessary to allow the fabric to be carried over and fastened to the inside without cutting the

goods to fit a square corner, as would otherwise be necessary.

Fig. 6 shows the finished body installed on a Packard chassis. A. L. Knapp, of the Packard company's engineering department, is to be credited with some of the original initiative prior to actual construction of the body. Fig. 6 does not do justice to the body, owing to haste of work preparatory to shipping.

The illustrations show an absolutely new method of body construction. This is the first body that has been made using fabric entirely for the panels. It is the most radical innovation in body construction that has been introduced since the advent of the motor car. Moreover, the initial idea and the first experimental work were by a man who is not a body-builder. I feel in duty bound to give credit to Mr. Childs for having the courage of his convictions and providing the money to try-out his theory.

Practical Considerations

Considering this form of construction from the practical point of view, let us consider the appearance first. The most expensive bodies, those that are built for the highest-price trade, have the top, upper back and rear side-quarters of leather. We can remember that in the carriage days the leather Victoria-top added a charm to the body design that has never been equalled. The high-finished, long-grain landau-leather used always adds a satisfying finish to the body. These comparative statements regarding leather refer, of course, to the conventional form of using it, in which part of the body is painted. The subject of this paper is a body that is covered entirely with a fabric that is a perfect duplicate of landau leather. Therefore, it will be necessary to show it to the public before the idea can be realized completely.

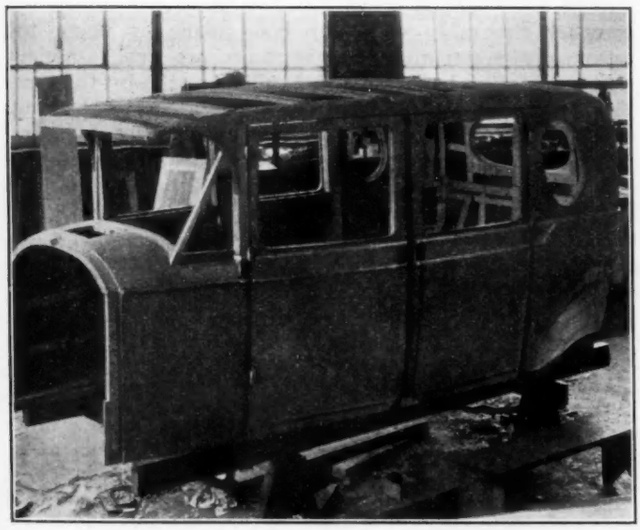


Fig. 4—Exterior of the Body with the Moldings Temporarily in Position and Ready for the Fabric Covering

The point that the public probably will be most skeptical of is durability. The matter of durability has two angles. First, regarding the lasting quality of the finish, the experimental product has withstood the test of all weathers for 2 years; it is still in daily use, and the foundation of the coating is so well preserved that a little friction with a soft cloth will brighten it so that it looks almost like new. The care to keep such a body looking fit is as nothing when compared to what is required for a painted surface; it does not need to be washed, but simply to be dusted-off with a cloth and, occasionally, to have a little polish rubbed-in. The other angle respecting durabiliity is whether a body so made will stand-up in average use. Lapse of time will be required to ascertain this.

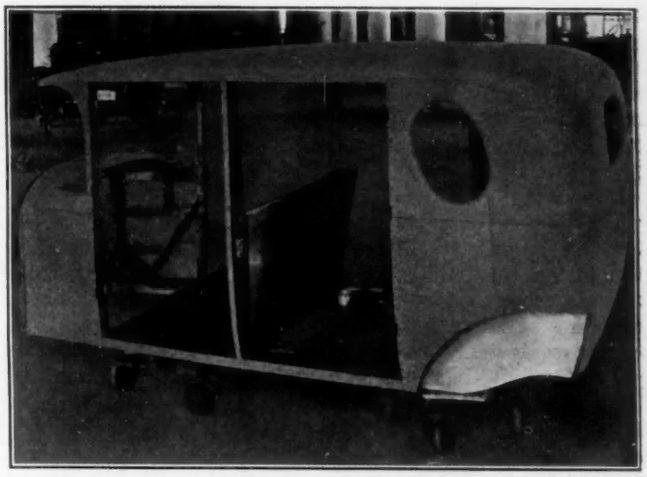


Fig. 5—The Fabric Covering Applied

In working on this body, no thought was given to the fact that the construction was exceptional. We know that, in all body construction, extreme rigidity is a "weakness." We must provide for compensation to take care of the weave, just the same as is done in bridge building; so, any form of body construction will stand-up that will absorb the shocks and return to its original shape after distortion. We believe that this form of construction has wearing qualities that will surpass those of many of the metal-panel bodies now made. It is reasonable to say that it will make the ideal all-season body, because the fabric covering should be warm for winter use and, in summer, as there is no medium to conduct the heat, it may prove to be equally as serviceable as the body that is composed of metal panels.

The weight of a body made as illustrated is slightly less than that of an aluminum-panel job. The weight of the combined wire, buckram and fabric is less than ¾ lb. per sq. ft. Aluminum construction weighs approximately ⅞ lb. and steel 1½ lb. per sq. ft. The size of the wood framing is the same as for aluminum or steel construction; the steel body-braces are likewise the same, as also are the doors, roof and windshield. In designing, we made no addition to the construction above that required for the conventional light-weight metal-panel body,

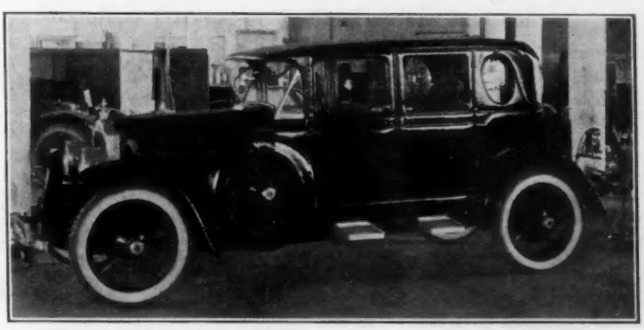


Fig. 6—The Completed Body Mounted on a Chassis

and we are confident that we have given our customer a serviceable body.

The flat cost of the covering and foundation material on this sample body was 26 cents per sq. ft. Aluminum would cost 30 cents, and steel, 7 cents per sq. ft. To the cost of both aluminum and steel construction stamping or hammer costs must be added, as well as the costs of finishing and then painting. In 6 weeks from the time of receiving the order, this body was completed and on its way. This included considerable work that would not ordinarily be required; special mudguards, side splashers, spare-wheel brackets, trunk brackets and the like. The amount of the work of designing, and that of the mill work and framing, are the same as for the ordinary body, but a great saving is gained in finishing. Two men completely finished the exterior and the interior of this body in two weeks. The entire outer-surface work was finished first. During the time of completing the work I realized how different the conditions would have been if this body were made with a painted surface. At no time was it necessary to admonish the workmen to keep their hands off, and no special attention was required to protect the fabric surface; but, had the surface been painted, the care of the finish would have been of prime necessity. Even when it was put into the freight-car for transportation, the body was not covered; if this form of construction has no other merit than that of having a surface that is rugged and does not deteriorate from indelicate handling, it cannot fail to win its way into general use.

The body has one other commercial merit. Reference was made previously to the amount of time saved in enameling the surface as compared with painting. We make the same claim for the fabric-covered body. One day's labor is ample to cover the exterior of a body with fabric. This represents a gain of from 5 to 11 days, according to the quality of work. This form of construction has the merit of the combination body in that the process is flexible, and changes in design can be made without sacrificing expensive jigs and tools. Moreover, the form or shape of the body does not have to be considered as in the case of a metal-covered body, because the wire, buckram and fabric can be applied as easily to a rounded surface as to a straight one.

The question naturally arises as to why this method of making bodies did not come forward earlier, since efforts have been made to use leather cloth. I want to spread the information that the fabric so often called imitation leather should be called by its proper name, leather cloth. Leather cloth has been made in only the semi-dull finish until recently, and there was not sufficient luster in the black color to please the eye. The high luster that is now obtainable will compare favorably with that of the finest landau-leather; therefore, the psychological moment seems to have arrived to make use of the material in question for body covering. It will withstand more rough usage than a painted surface will, and remain presentable for 2 years; it can then be rehabilitated by varnishing with carriage varnish.

Actual Advantages

The actual benefits that we have proof of, with the limited experience of making one sample-body of the construction just described, are less weight of body than results from any other method of construction; a body that can be fabricated more quickly, because the finishing is equal in time to enameling, an absolutely sound-proof body, because of its shock-absorbing quality; a comfortable all-seasons body, and a flexibility in construction, not equaled in any other method, that will permit what have been considered expensive shapes to be made cheaply. We feel that we have demonstrated unquestionably, in this experimental job, that we have made a body that in finish, design and attractiveness will compare favorably with any body made by using the customary materials. Furthermore, we feel confident that production bodies can and will be made by this new plan, and that they will be cheaper and better looking, because there is not the necessity of having so many manufacturers follow the stereotyped fashion. It is possible, also, to use various colorings of fabric. Thus, all the benefits of former practice are at the command of the fabric-covered-body builder, as well as several additional advantages.

STANDARDIZATION OF OIL-FIELD EQUIPMENT

THE following resolution proposed by representatives of the Board of Directors of the American Petroleum Institute was unanimously adopted at the meeting of that organization held in St. Louis during the early part of the month of December:

Resolved, By the group session on standardization that it is their judgment that standardization, simplification and improvement of oil-industry equipment and methods is necessary and desirable and will result in great economics; and be it further

Resolved, That the Board of Directors of the American Petroleum Institute be requested to declare it to be the policy of the Institute to encourage and to bring about standardization and simplification of oil-industry equipment and methods where desirable and practicable and to this end that the Board of Directors of the Institute be requested to appoint such committees of the oil industry as may be advisable to carry on the work in cooperation with the executive staff of the Institute and with the various agencies already contributing valuable work on the subject, such as the American Society for Testing Materials, the simplification bureau of the Department of Commerce, Bureau of Mines and the Bureau of Standards

Standards Committee Meeting

THE reports of Divisions, as printed in the December issue of THE JOURNAL, with the exception of that on Rating of Storage-Batteries, were duly considered and acted upon by the Standards Committee at its meeting on Tuesday, Jan. 9, at which Chairman E. A. Johnston presided. Two reports, which are printed in this issue of THE JOURNAL, but had not been prepared prior to the issuance of the December number of THE JOURNAL, were acted upon. These related to revision of the present standards for Roller-Chains and Roller-Chain Sprockets, and a proposed Recommended Practice for Tail-Lamp and Registration Number-Plate Illumination by the Lighting Division.

The action taken by the Standards Committee was reported to the Council at its meeting immediately thereafter and to the Business Session of the Society the next day and approved for submission to the voting members of the Society for final letter-ballot on adoption by the Society as S. A. E. Standards and Recommended Practices. The regulations governing the casting and recording of the letter-ballots require that they be returned to the Society within sixty days following the Annual Meeting of the Society. The letter-ballots will therefore be counted on Monday, March 12.

In casting their letter-ballots, Members should refer to the reports as printed in the December issue of THE JOURNAL, commencing on p. 529. In the discussion of each report that follows in this issue, each subject, with its page reference only, is given except for reports that were revised and the special reports mentioned in the foregoing paragraphs.

The session was opened with 42 members in attendance by Chairman E. A. Johnston. He first introduced Calvin W. Rice, secretary of the American Society of Mechanical Engineers, who gave a short talk on the International Engineering Congress recently held in Brazil. In introducing Mr. Rice, Chairman Johnston said in part:

> We are assembled at this session of the Annual Meeting of the Society to receive the reports of Divisions covering the work that has been passed upon by them since our meeting last June. Some of these reports are of extreme importance and will require considerable time for adequate discussion before passing upon them.
>
> As is well known, this Society was one of the earliest proponents of engineering standardization, and has fostered this work industrially for many years. Within recent years there has grown up a broader appreciation of its great value to the industry, so that now our work is national as affecting all of our industries and is very rapidly receiving serious international consideration. We should keep as well posted as possible regarding the international situation in order that our efforts may be adequately helpful and that the greatest benefit to all industries may be had.
>
> Calvin W. Rice, secretary of the American Society of Mechanical Engineers, who was a member of a mission from the United States which attended the International Engineering Congress in Brazil recently, has kindly offered to make a few remarks regarding the international standardization movement as brought out at the conference and as to the status of standardization in foreign countries. It is a pleasure to introduce Mr. Rice to you.

Mr. Rice spoke as follows:

Not only is the prosperity of your industry, but of this Nation, dependent upon the work that you are doing in standardization.

The United Engineering Societies joined in making me a delegate to the International Engineering Congress and I took advantage of that trip to make a tour of South America and call upon all of the engineering societies. Having been active in the Inter-American High Commission, I sought a commission from Secretary Hoover, so that the Inter-American Commission might be a factor for good in the nations that form the Pan-American Union. He was glad to do that, and gave me a letter to the Minister of Finance of each nation.

After we arrived in Brazil, I saw one of the elder statesmen, who said, "Why do you not have a suggestion for standardization come from the Congress?" So it was put through as a resolution of the International Engineering Congress, that standardization, elimination of waste, simplification of product, all known throughout the world as examples of American enterprise, should be introduced in the countries of the Pan-American Union. As you know, in Germany they have a word "Amerikanische," which means "the American method of doing things." This much has been accomplished.

Verne Le Roy Havens, the editor of *Ingenieria Internacional*, a Spanish publication of the McGraw-Hill company, has been the permanent secretary of the International Engineering Congress, and he will write all the governments of the 21 countries forming the Pan-American Union, advising the organization of standardization bureaus in each of them. None exists except in our own.

PROGRESS OF STANDARDIZATION IN SOUTH AMERICA

I am happy to report that since I have returned Brazil has acted, and last week I received a letter announcing that they had cabled to Secretary Hoover for the loan of Dr. W. E. Emley, who is down in Rio de Janeiro now, representing the Bureau of Standards in connection with its exhibit at the Exposition. I assume there is no doubt the Government will loan Doctor Emley to assist Brazil in establishing a Government bureau on standardization.

I uniformly called on the ambassador in each nation and explained the mission; then on the engineering society; then on the president of the local engineering society, and, in the case of Argentina and of Cuba, where we have associations of members of engineering societies of the United States, I took the presidents of those associations to call on the government. We proposed to the government in each country that they organize a bureau of standardization, for the benefit of that country. Then I got the officers of the local societies and of our own organizations to pledge to the respective governments their services, in the same way that this Society renders service to this Nation through its Standards Committee.

I want you all to feel, and you should tell the companies you serve, if you are officers of companies, that they ought to furnish the funds gladly, either by appropriation or paying the expenses, and allow the time of your staff to attend meetings of your Standards Committee Divisions, because you are promoting the prosperity of this Nation. If the Nation is prosperous, your industry will be prosperous. That gospel was preached in every country in South America.

People have been going to South America for 400 years to exploit the country. Pizarro, when he conquered Peru, for his first ransom on the head of the Inca chief who gave a banquet in his honor, exacted $15,000,000 gold, taken from the temples which that Inca chief had; and then after he had obtained that money, Pizarro murdered that chief and 1000 of his chieftains in cold blood. That is the worst story of perfidy in all history, but there have been lesser visits and methods all these years. I want you to feel that, for once, a different type of mission went to South America; that the engineering profession, represented by the citizens of the country and by our representatives who go to these countries, either temporarily or permanently, shall contribute their talents to the welfare of that nation.

It is to be expected that Mr. Havens, in his capacity as Secretary of the International Congress, will notify officially each country of this resolution of the Congress, favoring the establishment in each country of a bureau. Tomorrow morning I am to make my official report to Secretary Hoover, and, at my suggestion, we will meet in the Pan-American Union with all those departments of the Government that have anything to do with South America. There will be the Pan-American Union, the Inter-American High Commission, the Bureau of Latin Affairs of the Department of State, the Bureau of Foreign and Domestic Commerce of the Department of Commerce; then I hope that by invitation the Bureau of Standards will be there, and also the Bureau of Simplified Practice of the Department of Commerce and the American Engineering Standards Committee. I hope to pull all of those forces together and establish, gradually, commencing with Brazil, these standardization bureaus. Just think how fortunate it is, that within two months the thing has been actually started and the United States has been officially invited to furnish a man to instruct the government of Brazil how to do it.

I want you to feel, secondly, that there is no one thing in the whole world so important as foreign relations. The whole world is looking to the United States, and nothing could be better than for the engineering profession to be one of the groups of citizens of the world to have a definite job, like standardization. It is of enough importance to be worthy of all of your energies and, as you go ahead in your work of standardization, I want you to feel that you are helping this Nation to be prosperous and helping to bring all nations closer together and, if possible, make war unthinkable.

In proposing a vote of thanks to Mr. Rice for addressing the meeting, C. F. Clarkson pointed out the increasing importance of our trade with South America, relatively speaking, in our foreign commerce. He also spoke of the sincere and generous feeling on the part of Mr. Rice for the Society, who is, in his opinion, a very keen and good judge of economic values in the professional field.

Action on Division Reports

The following tabulation indicates the recommendations, presented by the different Divisions, that were accepted at the meeting of the Standards Committee and approved by the Council, and also by the Society at the Business Session of the Annual Meeting for submission to the voting members of the Society by letter-ballot. For subjects that were approved as printed in the December issue of THE JOURNAL, page references to that issue only are given. The additional reports that were presented at the Standards Committee meeting are printed in this issue of THE JOURNAL, as are also statements of the changes that were made in certain of the reports. These should be noted in the reports published in the December issue of THE JOURNAL.

REPORTS ACCEPTED AND APPROVED

Axle and Wheels Division	
Passenger-Car Front-Axle Hubs	p. 529
Chain Division	
Roller Chains and Roller-Chain Sprockets	Printed in this issue
Electric Vehicle Division	
Electric Vehicle Motor Rating	p. 535
Electrical Equipment Division	
Generator Flange-Mountings	p. 536
Starting-Motor Flange-Mountings — Outboard Type	p. 536
Starting-Motor Flange-Mountings—Inboard Type	p. 537
Starting-Motor Pinions	p. 537
Magneto Mountings	p. 537
Spark-Plugs	p. 537
Engine Division	
Flywheel Housings	p. 538
Frames Division	
Running-Board Brackets	p. 539
Iron and Steel Division	
Iron and Steel Specifications	p. 539
Lighting Division	
Electric Incandescent Lamps	p. 539
Tail-Lamp and Registration-Number-Plate Illumination	Printed in this issue
Lubricants Division	
Crankcase Lubricating Oils	Revised at meeting
Nomenclature Division	
Automobile Nomenclature	p. 541
Parts and Fittings Division	
Plain Washers	p. 541
Rod-Ends	p. 542
Passenger-Car Body Division	
Door Locks and Handles	p. 542
Wood Screws	p. 542
Plate Glass	p. 542
Screw-Threads Division	
Gages and Gaging	p. 543
Storage-Battery Division	
Rating of Storage-Batteries for Isolated Electric-Lighting Plants	Revised at meeting
Storage-Battery Monobloc Containers	Revised at meeting
Transmission Division	
Clutch Facings	Revised at meeting
Truck Division	
Vertical Dumping-Hoist Platforms	p. 546
Three-Joint Propeller-Shafts	p. 546
Body Hold-Down Clamps	p. 547

In addition to the reports listed in the foregoing tabulation, a progress report on Differential Gears was submitted by the Axle and Wheels Division, the Truck Division presented the report on Motor-Truck Cabs that was printed on p. 547 of the December issue of THE JOURNAL, as a progress report, and the report of the Ball and Roller Bearings Division on Metric Type Thrust Bearings, that was printed on p. 536, was referred back to the Division.

The discussions on all of the reports presented at the Standards Committee meeting are printed below.

AXLE AND WHEELS DIVISION REPORT

PASSENGER-CAR FRONT-AXLE HUBS

(*December issue of* THE JOURNAL, *p.* 529)

THE DISCUSSION

C. C. CARLTON:—This report, which embodies a year's work, can be discussed very briefly or at great length, as you wish. A year ago standardization of truck front hubs as S. A. E. Recommended practice was accomplished. This proposed S. A. E. Recommended practice is for passenger-car front-hubs. It follows current practice very closely, and is not an attempt to set up a final S. A. E. Standard. It is largely a compilation of current practice into a recommended practice rather than the ultimate of what can be accomplished in passenger-car hubs. We wish to call particular attention to the personnel of the Division and Subdivisions that have worked it out, because practically every manufacturer of the article in question is represented therein.

The ball-bearing hubs have not yet reached the point where they can be standardized.

CHAIN DIVISION REPORT

ROLLER CHAINS AND ROLLER-CHAIN SPROCKETS

(*Proposed Revision of S.A.E. Standards*)

This report, which relates to two subjects, was finished after the December issue of THE JOURNAL was printed. It is the result of several years' work done jointly by the Chain Division and the Transmission Steel Roller-Chain Committee of the American Society of Mechanical Engineers and its technical subcommittee. The art of designing and manufacturing roller-chains and their sprocket tooth-forms has been studied very carefully by the chain manufacturers with the object of developing standards that would bring all makes of chains, sprockets and their cutters to a common basis and assure a high quality of product and satisfactory operation.

The report embodies revisions to be made in the present S.A.E. Standards shown on p. E3 of the S.A.E. HANDBOOK. The revision will include illustrations of the sprocket tooth-forms and their controlling dimensions.

Much effort was made, particularly when the present standards were being formulated, to effect uniformity with British chain practice, but it has not been possible to accomplish this entirely, although with the standards as now developed interchangeable operation can be had where necessary. The principal differences between American and British practice lie in some of the chain widths and roller diameters and to some extent in the sprocket tooth-forms. Therefore

The Chain Division recommends that the present S. A. E. Standards for Roller Chains and Roller-Chain Sprockets, pp. E3 and E4 of the S. A. E. HANDBOOK, be revised as follows:

Roller Chains

(1) The following note refers to the formula for minimum breaking-strengths:

Note.—These loads are those at which the chains may break or become permanently stretched. The actual *working* loads may range from 1/6 to 1/50 of the ultimate-strength, depending upon the speed, the number of teeth in wheels, the conditions of lubrication and the pulsations arising from either the power or the load end. Chains should not be selected on the basis of breaking-strength

(2) The Standard Measuring Load is to be changed from "1 per cent of the average breaking-strength" to "1¼ per cent of the *minimum* breaking-strength"

Reason.—The minimum allowable breaking-strength is given by a formula. The average breaking-strength is not

(3) The Test-Load is to be changed from "one-third of the average breaking-strength" to "40 per cent of the *minimum* breaking-strength"

Reason.—Same as in (2)

(4) The system of naming chain parts, p. E3c, is to be changed as follows:

Assembled Pins, instead of pin link, consist of *one* pin-link-plate assembled with two pins

Pin Link consists of *two* pin-link-plates assembled with two pins

Connecting Link consists of a pin link with one detachable pin-plate

Roller-Chain Sprockets

(5) The standard tooth-form for block and twin-roller chains shall follow the same specifications as those for a roller-chain tooth-form for the same angle of bend

(6) Recommended minimum cutter-diameters are to be as given in the table

(7) Recommended widths of cutters are to be as given in the table

(8) Revised tooth-form and cutter outlines are to be in accordance with given diagrams

(9) Minimum diameter of the sprocket blanks for roller-chains to be equal to $P\,[0.6 - (\cot 180°/T)]$

If it is desired to have the entire range of teeth produced by a single cutter brought to a sharp point, this diameter should be slightly increased

(10) Uniform designations for the four principal types of sprockets shall be

Type *A*—Plain-plate
Type *B*—Single-hub
Type *C*—Double-hub
Type *D*—Detachable-hub

THE DISCUSSION

W. F. COLE:—The first four sections of the report provide for a slight revision of the formulas and dimensions that have already appeared in the S.A.E. HANDBOOK. (5) is really a corollary of (8).

(6) and (7), regarding certain dimensions of cutters, also follow as a corollary to (8) and if that is adopted they would naturally also be adopted. The tables simply list the dimensions that are worked-out from the diagrams.

(8) is in some respects the most important of all. Recently the Society adopted some standard tooth-forms that were published in the S.A.E. HANDBOOK on pp. E4a and E5. Very careful consideration was given to the working portions of the tooth and no material change in them is desirable. The height of the tooth, however, which is a rather inconsequential element, was originally set somewhat arbitrarily, with the result that in working-up the cutter designs in detail it was found that the height of tooth first adopted, while readily produced with single-purpose cutters, restricted the use of certain hobs and cutters that it was desired to make to cover more than a single pitch as well as a range of teeth.

Having found also that the formula which we had adopted, and which was published in the S.A.E. HANDBOOK, for laying-out teeth, does not readily lend itself to practical use, we have taken the opportunity when revising the height of the tooth to simplify the formula.

(9) is also really a corollary of the preceding sections.

(10) is a uniform designation for the four principal types of sprocket; Type *A*—plain-plate, Type *B*—single-

hub, Type *C*—double-hub, and Type *D*—detachable-hub. This is included in the report for the sake of uniformity in specifying these various forms.

ELECTRIC VEHICLE DIVISION REPORT

Electric-Vehicle Motor Rating

(*December issue of* The Journal, *p.* 535)

THE DISCUSSION

E. L. Clark:—The recommendation of the Electric Vehicle Division with regard to the rating of electric-vehicle motors was prepared to place all motors of different makes on the same rating basis. It is based on the standards of the American Institute of Electrical Engineers for the type of motor under consideration, the only difference therefrom being, as noted in the last paragraph of the report, that the time specification has been changed to a 4-hr. from a continuous basis, and the words "at normal rated load" added at the end of the second paragraph.

ELECTRICAL EQUIPMENT DIVISION REPORT

Before presenting this report, F. W. Andrew, chairman of the Division, stated that the Division meetings had been unusually well attended during the past year. At least two of the very large manufacturers who had not had members present heretofore had found that they could not afford not to be represented at the meetings.

Generator Flange Mountings

(*December issue of* The Journal, *p.* 536)

THE DISCUSSION

Leonard Ochtman, Jr.:—I do not know to what extent lock-washers are used under the shaft nuts. In many cases an S.A.E. Standard plain-washer 3/32 in. thick would be used and the shaft should be extended 1/32 in. so that the unit will not project beyond the end of the thread.

F. W. Andrew:—In that connection we were careful to canvass the gear and engine manufacturers. They told us that the shaft should not be even 1/32 in. longer. The lock-washer shown is a standard. Some sort of a bearing under the nut is necessary, probably in the form of a washer. It was the unanimous opinion of the Division, representing practically all the larger electrical manufacturers, that this is a very good standard.

E. W. Weaver:—Is not the plain washer thinner in all cases than the lock-washer for the same inside diameter, and would not this overcome the restriction?

R. S. Burnett:—There are three series of lock-washers; special-light, regular and special-heavy. The special-washer for this size has the same light thickness as the plain washer. The regular and special-heavy lock-washers are considerably thicker.

Edward Wallace:—I notice that the difference between *D* and *E* is about 1/32 in. If the 7/32-in. dimension to the cotter-pin hole were used, would the pin fit properly into the nut?

Mr. Andrew:—Yes. The reason for the 7/32 in. dimension is that every manufacturer without exception will want a center-hole in the shaft-end. It is not desirable to break through in drilling the cotter-pin holes because this breaks the drills. This point has been provided for and carefully checked.

Spark-Plugs

(*December issue of* The Journal, *p.* 537)

THE DISCUSSION

Mr. Andrew:—This report on spark-plugs was submitted to the Electrical Equipment Division by a Subdivision of which O. C. Rohde was chairman. It was well thought out. At our Division meeting we spent considerable time discussing it and finally accepted it as now submitted.

Earle Buckingham:—Are the threads at the base of the spark-plugs the same as specified in the former standard or have the tolerances been changed to agree with the National Screw Thread Commission tolerances for that size?

O. C. Rohde:—After the meeting of the Electrical Equipment Division there was received a report on thread tolerance from the Screw-Threads Division, which was approved by letter-ballot, but is being held pending final settlement by the National Screw Thread Commission, and a Sectional Committee, sponsored by the Society and the American Society of Mechanical Engineers, which is reviewing the Commission's report.

Charles M. Manly:—What is the relative amount of production in this Country of the two-piece spark-plugs of the 7/8-in. size thread, for which I understand this enlargement is principally needed? It seems to me that this is a very important matter because of the question of there being so many spark-plugs standards requiring as many different sizes of wrench. This is one of the matters that has been taken up by Secretary Hoover's Division of Simplified Practice to reduce waste. This proposed change, if made, may result in simply adding another size, because I question very seriously whether the people who make spark-plugs of the one-piece type will really change over. There are thousands of users already equipped with spark-plug wrenches that fit the 7/8-in. hex. If we make this change we will have to answer to the public.

Mr. Rohde:—We have gone into this matter very carefully. Ever since the 7/8-in. hex standard was adopted by the Society the production of the two-piece plug, which requires a larger hex-size, has been about 60 per cent of the total production. That means that the 7/8-in. hex has never really become the general standard.

The present inside dimensions of both the two-piece and the one-piece spark-plugs have been used for the last 10 years. A change from a 15/16-in. to a 7/8-in. hex is impossible in the two-piece construction with the established inside dimensions for the gasket and porcelain. On the other hand, a change from a 15/16-in. to a 7/8-in. hex in the one-piece plugs requires only a resetting of the milling cutters. Both types are made from the same size stock, which measures 1 1/8 in. on the outside. The difference in the actual clearance with the two hex-sizes amounts to about 1/16 in. on the diameter across the corners.

Some argument has been advanced that we need a smaller hex-size because of the decreased clearances between the cylinders of some engines. When we come to that we will need a new-size plug with a hex and a thread-size smaller than the present standard. We are limited now by the outside diameter of the gasket, which was standardized at 1 1/8 in. for the 7/8-in. thread. In fairness to the two-piece spark-plug manufacturers we should change this standard. There are two points to be considered in this connection; efficiency as affecting interchangeability and fairness to the majority of the trade. I believe that the 15/16-in. hex in all types of plug will make a better, more efficient plug because it is less susceptible to wrench-strain, and it will make it possible for the two-piece spark-plug manufacturers to make an S.A.E. Standard plug without having to revolutionize their business.

Mr. Manly:—Figuring on the basis that, of 5,000,000

or more cars, 40 per cent are at present using the 7/8-in. standard, something like 2,000,000 wrenches would be immediately junked if the hex is changed. I hold no brief for the manufacturers of either the one-piece or the two-piece plug, but I am interested in the effect on the users who exist to the extent of some 2,000,000 at least, and are equipped with the 7/8-in. wrenches. I do not like to see the Society complicate the situation by adding to the so-called waste. I happen to be on a committee that was appointed to cooperate with Secretary Hoover in his prevention-of-waste program. It does not put us in a good position to have to go before this committee and say that we have scrapped 2,000,000 wrenches.

MR. ROHDE:—The one-piece spark-plug makers produce a large volume of plugs with 15/16-in. hex because there is a big demand for them. The one-piece plug with the 7/8-in. hex is required on very few cars. There is only one car that makes it necessary to use the 7/8-in. hex. There are a few cars with close clearances, on which a 15/16-in. hex plug can be used without any particular trouble. I do not believe we are going wrong in this change because we are decidedly doing something that will benefit the majority.

MR. ANDREW:—Seven-eighth-in. two-piece plugs are being made. They probably constitute 20 per cent of the production of that type of plug. I believe that Marmon, Overland, Oldsmobile and probably some others are using it. Their tappet-rods are so close together that they claim they cannot use a wrench that will take the 15/16-in. plugs.

I feel that the trend of development of two-piece plugs is toward the 15/16 in. If we are to set a standard at all, it ought to be 15/16 rather than 7/8 in. Sooner or later we will have to set a new standard for a smaller plug in all dimensions.

A. D. T. LIBBY:—I believe that those who are now making 7/8-in. plugs will still continue to make them, and that nothing we can do in the way of standardization will ever change the trend so far as the manufacture of the 7/8-in. plug is concerned. There is a demand for the 15/16-in. plugs and a satisfactory two-piece plug cannot be made with a 7/8-in. hex. That has been well considered and set forth in THE JOURNAL. Getting a well-made two-piece plug of the smallest dimensions possible, resolves itself into establishing the 15/16-in. hex standard.

I do not see that the question of wrenches enters into materially. We have 7/8-in. plugs in use and wrenches have been provided. The manufacturers who make 7/8-in. plugs will continue to furnish the wrenches with those plugs and those who make the 15/16-in. hex plug will furnish wrenches, but gradually more and more of the 15/16-in. plugs will be made.

MR. MANLY:—If this were a new proposition and we were trying to decide whether to make the plugs 7/8 or 15/16 in., I would be thoroughly in favor of the point of view that has been expressed. The Society has had a standard for a number of years. Now we propose to substitute the 15/16-in. standard for it, throwing all the former product into the scrap-heap, wrenches and all.

In view of the statement that sometime in the future there may have to be still another and smaller standard plug, it seems to me that a wiser move would be for the Society to have two standards, one for 7/8 and the other for 15/16-in. plug.

MR. ROHDE:—For years we have had two standard spark-plug sizes, 7/8 and 1 1/8 in. Then we adopted the metric size. In spite of the fact that those three sizes have been standardized, 60 per cent of all the plugs made during that time have been 15/16-in. hex, which was not standardized. Shall we continue a standard just because, as a matter of sentiment, we feel we ought to, or shall we specify the one that meets the majority of requirements and is really wanted by the trade? We will have two sizes, the 15/16 and 1 1/8 in. The question of a still smaller standard plug is entirely a matter of the future. Spark-plug manufacturers do not want it because it limits their working clearances. The car and engine designers may drive us to it eventually. We can wait until they do. We hope that they never will.

ENGINE DIVISION REPORT

FLYWHEEL HOUSINGS

(*December issue of* THE JOURNAL, *p.* 538)

THE DISCUSSION

J. B. FISHER:—There has been a demand for some time for something in the standard for flywheel housing limiting the space for the flywheel bolts and nuts. It was proposed last year that a clearance space 6 1/4 in. in diameter and 5/8 in. deep be provided. This was later changed to 6 1/2 in. in diameter, but was referred back to the Division because it was too limiting on the clutch design. Joint consideration by the Engine and the Transmission Divisions resulted in the recommendation now presented, which makes no reference to the diameter and therefore does not limit the clutch design.

IRON AND STEEL DIVISION REPORT

IRON AND STEEL SPECIFICATIONS

(*December issue of* THE JOURNAL, *p.* 539)

THE DISCUSSION

F. P. GILLIGAN:—The report of the Iron and Steel Division is more or less confirmatory of editorial revisions that seemed desirable. From time to time requests are received to recognize compositions varying slightly from the S.A.E. Standard compositions. In view of the fact that our standard compositions cover a majority of automotive requirements, the Division felt that it would be best to amplify the S.A.E. Standard for Iron and Steel Specifications by the inclusion of the proposed sentence in the first paragraph of Part I, p. D1 of the S.A.E. HANDBOOK.

With regard to the second proposal, all the other steels in the 3100 group have a sulphur limit of 0.045 per cent and this report is simply to confirm a sulphur limit of 0.045 per cent for steel No. 3115, instead of 0.040 per cent.

LIGHTING DIVISION REPORT

ELECTRIC INCANDESCENT LAMPS

(*December issue of* THE JOURNAL, *p.* 539)

THE DISCUSSION

HUGH M. PIERCE:—Has there been any recommendation with reference to the marking of incandescent lamps to indicate their rated candlepower?

W. A. MCKAY:—It is standard manufacturing practice to have lamps marked as to their candlepower.

TAIL-LAMP AND REGISTRATION NUMBER-PLATE ILLUMINATION

(*Proposed S.A.E. Recommended Practice*)

At a joint meeting held last June of members of the Illuminating Engineering Society's Committee on Motor Vehicle Lighting, and the Lighting Division of the Society of Automotive Engineers, a representative of the State of Massachusetts asked the two Societies to prepare standard rear registration number-plate illumina-

tion specifications for motor vehicles. A joint subcommittee was thereupon appointed which studied this matter carefully and gathered necessary information. The subcommittee held a meeting in New York City on Dec. 28 at which the subject and the accumulated information were reviewed and the proposed specification drafted for tail-lamp illumination of registration plates and recommendations made regarding the design of registration plates. These were considered at a joint meeting of the Motor Vehicle Lighting Committee of the Illuminating Engineering Society and the Lighting Division on the day following and revised somewhat. In view of the fact that the legislatures of most States will convene within the next 60 or 90 days and probably consider or enact legislation controlling tail-lamp illumination, it was the sense of the joint meeting that the proposed specification should be officially approved by the two Societies without delay.

Immediately following the joint session, the Lighting Division held a meeting at which the action of the subcommittee and of the joint meeting of the Committees of the two Societies was approved and it was unanimously voted to recommend the following for adoption as S.A.E. Recommended Practice.

TAIL-LAMP AND REGISTRATION NUMBER-PLATE ILLUMINATION

Introduction.—These specifications are intended to apply only to the illumination, by electric lamps, of opaque registration number-plates for use on automobiles, trucks, tractors and motorcycles.

Tail-Lamp.—A lighting unit used to indicate the rear end of a vehicle by a ruby light and to illuminate the registration number-plate.

Wherever reference is made in these Specifications to the registration number-plate it designates a rectangle 16 in. long and 6½ in. wide designed to bear the registration numbers, and located 1/16 in. in front of the plane of the front face of the plate-holder.

General Construction.—The opening in the lamp through which the light passes to the registration number-plate shall be covered with colorless glass and shall be sufficiently large so that the light will cover the entire surface of the plate.

The lamp and the plate-holder shall bear such relation to each other that the major portion of the light incident at any point on the registration number-plate shall make an angle of not less than eight deg. with the plane of the plate.

The lamp shall be weatherproof and dustproof and so constructed as to withstand the shocks and vibration to which it is ordinarily subjected in use.

Laboratory Test

Samples for Test.—The samples submitted shall be representative of the lamp as manufactured and as marketed, and shall include the bracket to which the registration number-plate is to be attached.

Marks of Identification.—Each lamp submitted must bear a distinctive designation prominently and permanently indicating the name or type of the lamp.

If the registration number-plate holder is detachable from the lamp, it shall bear the same distinctive name or mark as the lamp.

Incandescent Lamps.—Incandescent lamps used in connection with the laboratory test shall be of 2 cp., 6 to 8-volt rating, and of standard manufacture for automotive service. They shall be operated at 2 mean spherical cp. during the test. In the case of tail-lamps involving the use of special incandescent lamps, such incandescent lamps shall be submitted together with any necessary accessories.

Illumination Test—The lamp and registration number-plate holder which is included with the sample submitted shall be tested, using an incandescent lamp as provided above. The apparent illumination as measured on white blotting paper shall not be less than 0.5 foot-candle at any point on the registration number-plate. The ratio of maximum to minimum illumination shall not exceed 30.

Requirements for Acceptance.—No lamp shall be considered acceptable unless it conforms with the requirements for measured illumination and the ruby light is visible for a distance of at least 500 ft.

No lamp shall be considered acceptable that is found unsatisfactory for any of the following reasons: unstable or bad mechanical construction; unduly dark or bright areas or excessive contrast in the illumination on the registration number-plate; cut-off of illumination within 1½ in. of the plate measured perpendicularly to the plane of the plate at the edge farthest from the light source.

Proposed General Information

It was felt that inasmuch as the character of the registration plates is an important factor affecting the illumination specifications, the following should accompany the proposed specifications as General Information:

WHEREAS, the laws of the various States require that the rear registration-plates of motor vehicles be illuminated so that they are legible at a distance of approximately 60 ft., and

WHEREAS, it is impossible to accomplish the proper illumination of the registration plates with the present lighting equipment, and

WHEREAS, the various motor-car builders and the manufacturers of lighting equipment need a definite standardization of registration plates to comply with these laws, and

WHEREAS, the color combinations, size of plate, size of stroke and spacing are of vital importance, therefore be it

Resolved, it is the sense of this joint meeting of the Lighting Committee of the Illuminating Engineering Society and the Society of Automotive Engineers that no specification for lighting the registration plate can be practically applied unless there is a reasonable standardization of registration plates as regards

(1) Maximum dimensions of the area to be illuminated
(2) Design and spacing for digits
(3) Color contrast

The joint committees further suggest that such standardization might be approximately as follows:

(1) The area to be illuminated to be included in a rectangle not larger than 6½ x 16 in.
(2) The design and spacing of digits to be such that
  (*a*) The stroke will not be wider than ½ in.
  (*b*) The spacing between strokes not less than ½ in.
  (*c*) A space of not less than ¾ in. will be provided between each third digit
  (*d*) The opening in such figures as 3, 6, 9 and 5 will be kept wide so as to avoid confusion between them or with the figure 8
  (*e*) The colors will be so selected as to secure high contrast between the numerals and the background

It was also the sense of the joint meeting of the two Committees that the proposal should be submitted to the Motor Vehicle Conference Committee and that that Committee should give the proposal wide publicity and urge the Conference of Motor Vehicle Administrators

to give it its support towards adoption by all the States of uniform legislation.

It was furthermore the sense of the joint meeting that the Society of Automotive Engineers should be requested to continue work on the formulation of standard registration number-plate and bracket-mounting dimensions and mechanical-strength specifications.

LUBRICANTS DIVISION REPORT

CRANKCASE LUBRICATING OILS

This report, which was printed on p. 540 of the December issue of THE JOURNAL, was revised by omitting the Explanatory Grade-Names, which were referred back to the Division; adding "Cleveland Open Cup" to Flash-Points; "Tests shall conform to the methods of the American Society for Testing Materials; and changing "Average Saybolt Viscosity" to read "Average Viscosity, Saybolt Universal."

THE DISCUSSION

K. G. MACKENZIE:—Certain changes in the specifications that were made last November were not important so far as the specifications were concerned, and involved chiefly, I believe, extending the color scale so that color determinations might be made on all grades of oil. However, radical changes were made in the explanatory grade-names. For instance, Specification No. 40, which at the September meeting of the Division was agreed upon as Heavy, became Medium; Specification No. 50, which was Extra Heavy, became Heavy; and, most serious of all, Specification No. 60, which was Extra, Extra Heavy, became Heavy.

The first problem in automotive lubrication was the selection of proper lubricants. A number of the larger companies have grades that have been advertised and sold for a long time as light, medium and heavy. The new grading would seriously change this practice. It seems to me that what the Society desires is first that the oil companies recommend oils according to certain S.A.E. Specification Numbers and then that the petroleum refiners state in their advertising and on their cans that their trade-names and grades correspond to certain S.A.E. numbers. Of course, there is a difference of opinion as to what are light, medium or heavy oils, but it would be a serious thing for the Society to state definitely that a given oil is light, medium or heavy, if the statement did not agree with the majority of trade practices.

As a member of the Lubricants Division, I feel that not enough work has been done by the Society to determine what oils should be classified as light, medium, heavy or extra heavy. It is important to include some sort of explanatory grade-names in the specifications, but it is unfair to ask the manufacturers to make changes to conform to the grades that we may select today.

I would like to recommend action that would not meet the situation entirely but I think improve it by changing No. 40 from medium to heavy, and No. 60 from heavy to extra heavy, to bring the explanatory grade-names more into line with the present grading practice and provide for two light, two medium, two heavy, and four extra-heavy oils.

MR. MANLY:—It seems to me that this report should be adopted as S.A.E. Recommended Practice and its provisions tried out for a reasonable length of time before adopting it as S.A.E. Standard. I therefore move that it be approved for adoption as S.A.E. Recommended Practice. [The motion was seconded.]

J. W. STACK:—No standards have been established in the oil business as to what constitutes a medium, a heavy or an extra-heavy oil. One refiner's heavy oil may be another's medium grade. However, in the Mountain and the Central Western States heavy oils of the most popular brands today have over 500-sec. viscosity at 100 deg., which would bring them into the 60 class at 210 deg. The extra-heavy oils, including those for motorcycles and tractors, have about 100-sec. viscosity at 210 deg. For many years we have been marketing extra-heavy oils of about 100-sec. viscosity at 210 deg. and I think that an oil of 60-sec. viscosity at 210 deg. should not be known as an extra-heavy oil.

H. C. MOUGEY:—For a long time the Division did not recommend the use of explanatory grade-names, but there seemed to be an insistent demand that some sort of descriptive names be coupled-up with the specification numbers since so many people are in the habit of referring to oils only as light, medium, heavy and extra-heavy. We found that it was impossible to assign a definite name, such as light, medium or heavy, to a definite specification, and the groups into which we classified the several oils, light, medium, heavy and extra-heavy, were the best compromise we could make inasmuch as the oil industry itself had not standardized on the viscosities of oils that are sold under the different classes.

MR. MACKENZIE:—In regard to Mr. Stack's remarks, I would say that the Texas Co. has marketed to its entire satisfaction an extra-heavy oil that corresponds to the proposed S.A.E. No. 60. Of course, this is a naphthene-base oil. I think that the general classification followed by the Texas Co. is followed almost unanimously by those firms which market naphthene-base oils.

I would like to offer an amendment to the motion, changing the explanatory grade-name of No. 40 from Medium to Heavy, and of No. 60 from Heavy to Extra Heavy, because I think some of the companies would like to tell the public now to just which of the S.A.E. Specifications they will conform. (This motion was seconded.)

CHAIRMAN E. A. JOHNSTON:—Is that amendment acceptable to you, Mr. Manly?

MR. MANLY:—I confess that I do not know very much about oils technically but, to bring the matter to an issue, I accept the amendment. [The amendment was accepted by the seconder of the original motion.]

H. S. PIERCE:—If some confusion will be brought about by changing the names now being used, why not simply use grade numbers?

MR. MOUGEY:—That was the intention of the Lubricants Division for some time, because the oil industry is not agreed on names that correspond to the different viscosities; but, as there was such a demand that names of a more or less descriptive nature be included in the specifications, this system was presented as a way of meeting this requirement without upsetting the commercial practices that differ among companies.

W. H. HERSCHEL:—There are two conflicting points of view that the Division has endeavored to reconcile. One is that of the refiners who have certain brands of oil on the market which they do not want to change. The other is that we want to help the purchasing agents who are accustomed to buying oils by certain names and designations of light, medium and heavy. We wish to avoid definitely naming specific classes of oils, so as not to limit the refiners. But to omit entirely any descriptive names would leave purchasing agents, who are unfamiliar with classification by viscosities, entirely at a loss when buying different grades of oil.

I believe that the strictness with which these specifications are intended to tie a certain explanatory trade-name to an oil of a certain viscosity has been over-

emphasized. The explanatory grade-names in reference to specific oils are merely given as a guide to purchasing agents as to approximately which grade of oil they may expect to be satisfactory for their particular use. If it is felt that the report implies that a definite specification-number should go with a definite explanatory grade-name, the grade names might be omitted and a statement made that in general such and such specification-numbers correspond approximately to such and such an explanatory name.

MR. STACK:—I believe the point that we have been discussing is relatively an oil-man's marketing problem and really not an engineering one. The report should be adopted as it stands inasmuch as the nomenclature was approved by the Division after a thorough survey of existing oils on the market.

MR. MACKENZIE:—At the conference in the City of Washington on Nov. 13 the matter was referred to a Committee of three, one representing the American Petroleum Institute, one the Society of Automotive Engineers and one the Inter-Departmental Specifications Committee. A majority report and a minority report were made on behalf of this Committee. The majority report, made by the two first-named members, approved the proposed grade-names; the minority report practically approved the old classifications.

MR. HERSCHEL:—As I recollect the matter, the minority report was in favor of using a different standard of tests for oils and did not really have a bearing in this connection, because it did not consider any system of names for the particular specification-numbers given in the Division report.

H. L. POPE:—What we need most is definitions as to what these grade-names mean. I do not see how it will be possible to satisfy all concerned until those definitions are agreed upon. I would like to suggest that the grade-names be eliminated from the report and referred back to the Division to prepare definitions for them.

CHAIRMAN JOHNSTON:—The motion before you is to approve for adoption as S.A.E. Recommended Practice the report as submitted, leaving out the descriptive names and including references to the Open Cup and the American Society for Testing Materials methods of testing.

[The motion was carried.]

NOMENCLATURE DIVISION REPORT

AUTOMOBILE NOMENCLATURE

(*December issue of* THE JOURNAL, *p.* 541)

THE DISCUSSION

MR. POPE:—To make much headway in its work the Nomenclature Division requires considerable time on account of the large scope and vast amount of detail involved. The main accomplishment during 1922 was to lay down a plan that, if properly carried out, will eventually give us a pretty complete nomenclature, covering all branches of the automotive industries. After the plan had been determined, an organization was gotten together which in the main has been gathering data that should result in some fairly complete recommendations during 1923. The subdivisions appointed are working on nomenclatures for Aeronautics, Highway Transport, Power Farming, Motor Transport, Motorcycles, Stationary Engine Operation and Industrial Service.

The Nomenclature Division report at this time recommends that the present Differential Nomenclature, included in Division 12, Group 4, of the present S.A.E. Standard for Automobile Nomenclature, be revised as outlined by the Subdivision and approved by the Gear Manufacturers' Association.

PARTS AND FITTINGS DIVISION REPORT

PLAIN WASHERS

(*December issue of* THE JOURNAL, *p.* 541)

THE DISCUSSION

MR. ANDREW:—In looking over the tolerance allowed on the thicknesses, it seems to me that ±0.010 in. is pretty liberal on a washer 1/32 in. thick.

F. G. WHITTINGTON:—We did not think that tolerance could do any harm, and certainly it would be less restrictive.

MR. ANDREW:—What material may these washers be made of?

MR. WHITTINGTON:—Usually of scrap stock, or stock that is not held very close to nominal thickness.

STORAGE BATTERY DIVISION REPORT

RATING OF STORAGE-BATTERIES FOR ISOLATED ELECTRIC-LIGHTING PLANTS

At the Standards Committee Meeting the Division presented a revised report in place of that printed on p. 545 of the December issue of THE JOURNAL. The revised report is printed below in full.

RATING OF STORAGE-BATTERIES FOR ISOLATED ELECTRIC-LIGHTING PLANTS

(1) Lead-acid storage-batteries for isolated electric lighting-plant service shall have two ratings, a continuous rating and an intermittent rating. The ratings shall be determined at an initial electrolyte-temperature of 80 deg. fahr. and be based on a final voltage of not less than 1.75 volts per cell.

(2) *Continuous Rating.*—The continuous rating shall be the capacity in ampere-hours of the battery when it is discharged continuously at the 8-hr. rate.

(3) *Intermittent Rating.*—The intermittent rating shall be the capacity in ampere-hours of the battery when it is discharged intermittently over a period of 72 hr. The standard test to determine this capacity shall be as follows:

Discharge at a current rate equal to 1/24 of the intermittent ampere-hour rating of the battery for an initial period of 4 hr., followed by a 16-hr. rest; then discharge at the same rate for two 8-hr. periods, each followed by a 16-hr. rest, and for a final discharge period of 4 hr.

The rest periods are arranged so as to avoid night work when the test is begun at noon.

(4) Except for the final voltage per cell, the ratings apply to nickel-iron batteries as well as to lead-acid batteries.

(5) Both ratings should be cataloged in the following form:

S.A.E. Ampere-Hour Capacity Rating: 100-140: The first number represents the capacity based on the continuous rating and the second number the capacity based on the intermittent rating.

THE DISCUSSION

W. E. HOLLAND:—The rating of storage-batteries for isolated electric-lighting plants has been under animated discussion for the last 4 years. After a number of meetings of the Isolated Electric-Lighting Plant Division, the Society adopted a 72-hr. intermittent rating but, as this did not prove satisfactory to the Farm Lighting-Plant group of the National Gas Engine Association or to a large number of the manufacturers, the Division of the Standards Committee attempted to standardize an 8-hr.

continuous method of rating. This also met with considerable opposition and the work came to a deadlock. There seemed to be no way out until the subject was recently reassigned by the Council to the Storage-Battery Division, and we decided that the only standard that could be recommended at this time is a double standard. This was done, after very careful consideration of the history of the work, by unanimous vote of the members of the Division.

As there was a slight objection to some of the wording of its recent report, the Division met this morning and came to a decision as to how the final recommendation should read.

Storage-Battery Monobloc Containers

This recommendation, which was printed on p. 545 of the December issue of THE JOURNAL, was revised by changing the last line under "Height from Top of Ribs to Top of Container" to read "Maximum variation of different compartments of the same container, 1/32 in."

TRANSMISSION DIVISION REPORT

Clutch Facings

The caption under the cut on p. 546 of the December issue of THE JOURNAL should read "Proposed Dimensions for Clutch-Facing and Rivet Holes," and the fifth line of the indented paragraph in the second column should read "the rivet-hole sizes" instead of "the rivet sizes."

TRUCK DIVISION REPORT

Before presenting the recommendations of the Division for consideration by the meeting, F. A. Whitten, chairman of the Division, reviewed briefly what had been accomplished in the past 6 months. He said among other things

> The Truck Division this year has endeavored to follow the practice of last year's Division, which seemed very commendable, by concentrating on the things that we thought could be done. We carefully studied all the subjects that were referred to us, and by a process of elimination finally decided to disregard certain subjects because they were not important, or it did not seem possible to formulate standards for them at the time.
>
> There are only two important subjects in progress, I believe, before the Division. The first is power takeoff shaft-ends, which is in the hands of a Subdivision for circularization and a report.
>
> The other very important subject which is still before the Division is that of motor-truck ratings, so-called. The name is rather indefinite. The subject was assigned as a special one to the Division because there seemed to be no doubt that in the licensing of trucks to operate, the Motor Vehicle Commissioners of the various States would be guided, to an extent that they never had been guided before, by the detailed construction and the safety of the trucks in operation. There are various reasons for this, some pertaining to highways and others to the safety of other vehicles on the highways. A number of suggestions were made as to the nature of possible recommendation and the matter referred to a Subdivision that has worked with the National Automobile Chamber of Commerce and other organizations interested in the subject. This was advisable because there are considerations more vital in some ways to the manufacturers than the engineering ones.
>
> It seemed at one time that the matter involved finding some way of regulating and registering the capacity of trucks and the strength of certain elements, such as axles, steering-gears and brakes, but procedure in this direction did not prove very practical. The subject is a large one and we can only report progress at this time.
>
> As a result of concentration on a few subjects the Division has made only three recommendations.

Vertical Dumping-Hoist Platforms

(*December issue of* THE JOURNAL, *p.* 546)

THE DISCUSSION

F. A. WHITTEN:—The first of our recommendations is on vertical dumping-hoist platforms; that is, the substructure on which vertical hoists of the hydraulic, screw-operated and plunger types are mounted on the chassis frame. This subject was taken up because various companies, in mounting the hoists, drill all sorts of holes in the frame, which results in weakening and sometimes the failure of this member.

It was originally intended to recommend certain standard dimensions, but this was not feasible because of the possibly necessary variation between designs.

Body Hold-Down Clamps

(*December issue of* THE JOURNAL, *p.* 547)

THE DISCUSSION

MR. WHITTEN:—In connection with the subject of Body Hold-Down Clamps, there has been a demand from various sources for improved methods of mounting bodies on chassis. Bodies, in the majority of cases, are not supplied by the truck builders and all sorts of means have been used for fastening them down. This has caused all of us more or less trouble.

UNACCEPTED RECOMMENDATION

BALL AND ROLLER BEARINGS DIVISION

Metric-Type Thrust Ball-Bearings

(*December issue of* THE JOURNAL, *p.* 531)

THE DISCUSSION

F. W. GURNEY:—There has been considerable discussion regarding this matter of metric bearing-sizes. We all know that there is great opposition throughout the Country to the general adoption of the metric system that has been dragged into this matter. I hope there will be a general expression of opinion and a clearing-up of misunderstanding on the subject at this time and I will ask H. E. Brunner to make the report for the Subdivision, as D. F. Chambers, who is its chairman, is not present.

H. E. BRUNNER:—Approximately a year ago, the Ball and Roller Bearings Division appointed a Subdivision to undertake the standardization of metric-type thrust ball-bearings by bringing the various manufacturers into agreement on definite sizes of bearings. This necessarily involved making concessions, and in this manner the dimensions of the thrust bearings as given in the report were selected.

The problem was one of getting the exterior dimensions agreed upon, the bores being practically standard at the time. While this is a proposed new standard, it is not necessarily a new series of bearings nor a new group of bearings. It antedates the so-called inch-dimension standard of today and, so far as the metric phase of the situation is concerned, I do not see why it should necessarily stand in the way of the adoption of a standard for a class of bearings that has been so generally used. This standard would make it better for the manufacturers by eliminating the difference existing in bearings of corresponding sizes.

J. T. R. BELL:—It seems to me that in view of the

opposition the matter should be postponed. There are many arguments for and against, and the subject ought to be threshed out more thoroughly.

MR. ANDREW:—Are not the bearings of this type we are now using predominatingly in metric sizes?

MR. BRUNNER:—Yes.

MR. ANDREW:—My company uses both metric and inch-size bearings. We find no difficulty whatever in putting inch-size balls into metric-size bearings. I think the matter should be carried at this time in favor of the metric bearings as they are already a standard in our Handbook insofar as the ranges of sizes and tolerances are concerned.

MR. MANLY:—In the consideration of this thrust-bearing proposition before the Division, the most important point was that we could not get, apparently, any real information on what is the general attitude of the American manufacturer toward the metric sizes. Those of us who have spent considerable time on this subject certainly urge that those here today speak freely on this whole question so we can get some idea of what the general attitude of the automotive industry is. We are bound to have metric thrust-bearings in aeronautical work and it will be very important to have the bearings interchangeable, but that will represent a small portion of the total automotive use of thrust bearings at least for the next few years and I think it is not important from the point of view of the total automotive production.

R. G. CORNFORTH:—The view of our company on the matter is that of the thrust ball-bearings used, the inch sizes are by far in the majority.

It seems that it has been the practice of the Society to standardize in inch dimensions and to avoid, if possible, all metric dimensions; in fact, the standards for American automobiles are almost entirely in inches. It has been the practice in international work for the country that leads in the production of any article to take the lead in setting a standard. Surely, there is no question that the United States is far in the lead in the automotive and the machine-tool industries. From these standpoints alone, I think it is reasonable to think that it would be a step backward to standardize in metric dimensions.

There was some thought during the war that we needed standardization in inch dimensions due to the fact that in the construction of airplanes we were unable to obtain bearings of foreign manufacture which were in metric dimensions. This confused the matter, and we had to make our own bearings. We were building planes to meet the demand overseas, the parts being interchangeable with the parts used there. However, airplanes are practically a new proposition. Inasmuch as they will be developed extensively in the years to come, let us start this bearing standardization right, and in the inch system.

MR. GURNEY:—Referring to one point that Mr. Cornforth brought out, there is no intent to supersede the present inch standard[1] that has existed for several years. The standard that is now proposed is one that is naturally based upon the old millimeter standard and has equivalents in inch dimensions. It might be mentioned that converting millimeters to inches gives figures in decimals that naturally have to be used in the production of anti-friction bearings. This proposed standard goes hand-in-hand with what may sooner or later be an international standard because at the present time considerable work is going on in that direction.

[1] See S. A. E. HANDBOOK, pp. C35 to C39.

MR. MANLY:—This matter is of much more importance than the mere discussion of the thrust bearings themselves. For more than 2 years a joint committee sponsored by the American Society of Mechanical Engineers and this Society has been working on this proposition in connection with the Swedish and German committees. O. Wikander, a member of this committee, is now in Europe getting further data.

I accepted membership on this committee largely to see whether or not there is any possibility of international standardization. If we can not agree on international standards in connection with ball bearings, there is no possibility of international cooperation in the matter of standardization. If it were a proposal in connection with threads or gears I feel it would be absolutely hopeless, because there are measurements involved that cannot be converted; there can be no interchangeability of either gears or screw threads.

As to ball bearings, we have the annular series, which are so extensively used that I imagine no one would favor such a handicap on industry as the abandonment of their metric sizes. This matter of thrust bearings brings up the question whether we shall have two standards, an English and a metric, for thrust bearings, so that there can be some guide toward eventual international standardization, or the Society shall take the lead in being absolutely opposed to any attempt to bring about international standardization of products?

This is a very big and important matter and should not be simply thrown back into the Committee's hands. We have been trying to ascertain the sentiment of the American industries on it, and do not want it settled merely on the basis of an international exchange-rate or by a League of Nations. We should have a free expression of opinion as to whether the Society is ready today to say that this one recommendation, which is the most likely of any I know of to be carried through as a matter of international standardization, shall be adopted, or we shall reject it and say that henceforth it will be of no use to talk about international standardization.

PRESIDENT B. B. BACHMAN:—I can readily understand that there is some demand for the metric-size thrust-bearing, for the reason that in automotive apparatus, and possibly other apparatus, it is used in conjunction with metric-size annular-bearings. Naturally, measuring instruments and tools can be interchanged readily if the dimensions are similar. On the other hand, there has arisen a large usage of the inch-size bearings, probably in connection with plain bearings and plain journals and that in this connection the inch sizes would be most logical.

We always have a difficult problem when a large body of experienced men attempts to divert by arbitrary action the course that experience has pointed out. We have among our present standards illustrations of attempts to create standards that in themselves were logical and defensible, but that, through commercial restriction, have never come into usage. This is a phase of the problem that we should consider very seriously.

The minority report printed on p. 535 of the December issue of THE JOURNAL relates in large part to the division of opinion regarding inch and metric dimensions, but it contains also the statement that some of the sizes presented can be criticized from a design standpoint. In my estimation that is considerably more serious than whether the bearings are in metric or inch dimensions.

As a matter of the Society's procedure, this is one of the cases in which complete discussion in Standards

Committee meetings is advisable. Whatever the outcome of our discussion may be, I thoroughly believe that where a logical division of opinion exists among competent minds on a subject of this character, action should be delayed until an agreement can be reached, irrespective of the merits of the two sides of the case.

Finally, I do not believe we will ever have adequate standards action by a majority vote; it should be by practically unanimous consent.

MR. POPE:—There is no question but we should try to use the inch measurements in all our work, but those who expect to get foreign business under present circumstances, in some cases at least, must compete with the foreign dimensions. If we want to sell in South America, for instance, or if any foreign country goes into South America with its goods, it must use the metric system unless there is sufficient merit in the article made to inches to compete with the metric article made in foreign countries.

We are building the Wright Hispano engine, which resulted from our building the French engines for the French Government, and have been using metric measurements. We are, however, designing our new engines in inch measurements, including the ball-bearings. But we might get a sufficient order from some foreign country to make it advisable to continue to build interchangeably with the French Hispano, the English Hispano and the Spanish Hispano. I can conceive of a ball-bearing manufacturer in this Country becoming so efficient in the production of ball bearings that he could compete with a foreign manufacturer, but in so doing he would have to supply the ball bearings that the foreign market wants. Unless we can convince such a market that the inch is the right standard, it will want the metric standard.

Can we not state in our standards that it is desirable and recommended that, so far as possible, American manufacturers design their product to English measurements for ball bearings, but that wherever a manufacturer is forced to make metric ball-bearings he should follow the metric standard?

EARLE BUCKINGHAM:—As I understand it, these metric thrust-bearings have the same bores and outside diameters as the metric radial bearings that we already have. I see no reason why the question of metric versus inch measurements should enter at all. I think there are not many here who would care to see the inch system of measurement abandoned entirely in favor of the metric. Neither do I see how the adoption of a series of thrust bearings like this would lead us in any way to that step. If we have a series of radial bearings and we wish to use thrust bearings in conjunction with them, it is essential that we have the proper bearings to do so.

I understand that these metric bearings are not proposed to the exclusion of the present standard of inch-type bearings that was formulated by the Ball and Roller Bearings Division some years ago for use where the inch sizes are preferable. I think the question should be decided solely on its own merits; if there is sufficient demand for thrust bearings of these general dimensions, I see no reason why we should not adopt them.

MR. GURNEY:—It should be understood that it is not the function of the Standards Committee to create new standards that it can force on the industry. What we ought to arrive at today is the facts as to what bearings of this type are at present being used or will be used.

There has been in existence for years a series of thrust bearings in inch sizes. This new line that the Subdivision has worked out is merely to recognize standards that are already in existence and use. That is all the Standards Committee can do, practically, anyway. We cannot reach up into the air and draw out standards that we can compel the industry to use.

It should be borne in mind that all the bearings originally laid out in the metric sizes, such as the annular bearing sizes, are being used and applied practically universally throughout the industry in inch dimensions.

I do not know of a single company in this Country that deals with these dimensions in metric terms, as the limits and tolerances are universally expressed in inch dimensions, usually in decimals carried out to the fourth place. The common limit of measurement throughout the industry is what we usually call the tenth, meaning 0.0001 in.

It is unfortunate for us that the original annular sizes that were established in Germany nearly 20 years ago were metric sizes. It would be fine if all of this could be wiped out and we could start anew with the knowledge and experience we now have. We could avoid considerable trouble.

The geometric progression of sizes is ideal and I wish it could be adopted, but this is practically impossible. It would mean the carrying along of two independent standards for a long time until one or the other should become obsolete. We know that the intervals between the sizes, the 5-mm. intervals on the bore and the 10-mm. intervals on the outside, are too great on the smaller sizes, but they are all right on the larger sizes. We very much wish that they might be changed to a geometric progression but none of us feels that we can afford to establish new sizes and double our whole equipment of jigs, fixtures, dies and gages.

MR. BELL:—I am not opposed to either one standard or the other. This matter, as it now stands, is a commercial one entirely. The five or six companies making ball bearings in metric sizes, who are the older and were until a few years ago the larger firms, are in the majority on the Standards Committee. One or two other companies are making by far the larger number of these thrust bearings which are used in steering-gears and clutches on practically every type of car; and so far as I can find out they are made in three to four times the number of the metric type.

This particular metric type of bearing has been in existence in these sizes from 16 to 20 years, the same length of time as the annular bearings, and is used by the majority of manufacturers.

MR. LIBBY:—I want to emphasize very strongly Mr. Bachman's thought that when we adopt standards we ought to have a practically unanimous vote. I have been on one of the Divisions for the last 6 or 7 years and I, too, have become convinced that that ought to be the rule.

It seems that there is a great difference of opinion on this thrust-bearing subject and that it ought to be referred back to the Division for further consideration and accumulation of data, with possibly consultation with the Aeronautic Division. I gather from the discussion that the percentage of these bearings in production is rather small. No great harm can be done by laying this matter over pending further development.

D. F. CHAMBERS:—As we all know, the metric system of bearings was inherited from Europe, particularly in the annular-bearing sizes. I do not know exactly where the demand came from for these metric-size thrust-

bearings, except that they have been made in this Country for about 15 years.

Our company must use both the inch and the metric systems on account of the demand. I was unable to gather very definitely in our 18 months' work just exactly what the requirements are in the number of sizes, or in quantity production, but certain sizes, mostly of the double-direction type, are in considerable demand.

With regard to whether the containers would have sufficient strength when using the larger diameters of ball with the proposed outside diameters of bearing, it has been agreed that the cage designs would be sufficiently strong. We used about 10 different companies' lists of bearings and from them worked up a compromise in sizes in the proposed standardization.

There was brought up at our meetings the matter of trying to standardize ball sizes. That is really impossible because the ball sizes, as well as the number of balls used, vary between makes and designs. Our only object in proposing the adoption of a standard is to establish the boundary or volumetric dimensions.

MR. MANLY:—This project did not grow out of the air. At least four companies have been listing metric-type thrust-bearings for many years. We had considerable trouble in getting thrust-bearings for our airplanes in 1915 and 1916 when the submarine campaign was shutting off importations pretty extensively. We had built a number of engines at Buffalo at the Curtiss plant that were designed to use S K F thrust-bearings. The submarines got some of the ships that were bringing the bearings over and our whole production was held up. We had to procure substitutes. We found that no two companies listing these metric-type thrust-bearings were working to the same dimensions. We, therefore, had to take some that were over-size and have them reground as the quickest way to meet the situation.

That impressed on me the importance of the American manufacturers and the American engineering societies cooperating with the Europeans in trying to bring some order out of the chaos that exists at the present time due to the lack of standardization for these thrust-bearings. We are not trying to force upon the American manufacturer the substitution of metric thrust-bearings for the inch thrust-bearings; nor do we recommend the use of one as opposed to the other.

There is, has been and no doubt will continue to be a certain demand for metric-type thrust-bearings. This report is simply an attempt to get those manufacturers in this Country who list metric-type thrust-bearings to do two things: to come together and adopt a standard to which they will all work, and to try to get such a standard lined-up with the work that is being done in Germany, Sweden and the other countries that are using the metric standard. When we do adopt some standard it should harmonize with the largest number of foreign standards and prevent at any time such trouble as has arisen before.

I am very sure that there will continue to be in aviation work a strong demand for the continuance of the metric-type thrust-bearings.

MR. CORNFORTH:—Let us not forget that we are leading in the building of automobiles; our product is widely used abroad in preference to foreign makes. When will the time be that American labor conditions will be such that we can meet competition with foreign labor? That is the chief thing that brings the cost of bearings up today. It seems to me that a metric standard would encourage importation and disrupt our market.

C. T. MYERS:—This Country not only produces from 80 to 90 per cent of the automobiles in the world but it will sell them all over the world. We are very much concerned not only in the building of these automobiles but in the servicing of them. Our products will have to meet competition abroad first as American cars, trucks and tractors, and then as individual machines.

It is of vast importance, considering the fact that the English dimensions are universally used in our own manufacturing, that we have first at least an English standard which will be in a proper ratio for various applications, because it is inconceivable that all the different automobile and truck companies will maintain service-stations throughout the world where they can service every part of their own cars. We must come down to the point where, by proper organization, a central warehouse can carry parts for practically all American cars.

I think that is the viewpoint we should bear in mind in this situation. We will have to fight for foreign trade. We ought to have standards that are our own, that conform with our own tool equipment, our own manufacturing methods. If the English-dimension series of thrust-bearing standards is not what it ought to be at present, the Division should undertake that piece of constructive work. If after that there is a demand for metric-size thrust-bearings in this Country, they should consider and submit such a standard because we should never again be in the position to which Mr. Manly referred of having to depend on a foreign manufacturer to furnish even the metric-size thrust-bearings that we may need.

MR. GURNEY:—It seems to me that this matter narrows right down to the question of whether the demand for these metric sizes is large enough and of sufficient importance for us to recognize it as a standard.

MR. PIERCE:—Mr. Manly spoke regarding the international standardization aspect of this case. I think that every time we attempt international standardization the problem of whether it shall be expressed in metric or inch dimensions will come up. If we accept and put on our records standards in the metric dimensions, it will in a way strengthen the other fellow's side of the case in the majority of instances. If we make and use our products almost exclusively in inch sizes and if we predominate in the production of any article, it seems to me the inch sizes should be used.

CHAIRMAN JOHNSTON:—This matter has been discussed thoroughly enough for us to make some decision. There is a motion before you, which has been seconded, that the proposed metric series of thrust bearings be adopted.

[A count of those voting in favor of and against the motion was taken]

CHAIRMAN JOHNSTON:—The motion is lost.

MR. MANLY:—I move that this matter be referred back to the Division that originally submitted it.

[The motion was seconded]

GEORGE R. BOTT:—The Ball and Roller Bearings Division has been functioning for about 8 years, and considerable has been done in the standarization of bearings. The standardization of inch-size thrust-bearings was accomplished after much work and the question of metric-size thrust-bearings has been before the Division for about 5 years.

After studying it we realized that there is very little objection to a metric standard for the reason that those who desire inch-size thrust-bearings can certainly obtain them, and if there is a demand for 1,000,000 or 2,000,000 bearings that demand should be filled. The standard-

ization of these metric-size thrust-bearings is not a question of whether we wish to use metric sizes or inch sizes, but a question of standardizing, making a fewer number of types or varieties of metric sizes. Of five makes of metric bearing, the sizes of which deviate possibly 1 or 2 mm., the bores are strikingly standard, and the outside diameters vary little. The differences are largely in the heights.

The effort in this work has been to standardize on a few sizes of metric thrust-bearing so that they will all be alike. That has its great advantages. It is not a question of placing the metric-size bearings before the manufacturers and demanding that they be used; it is a question of standardization by trying to eliminate large numbers of sizes.

It has been stated that the automobile industry desires inch-size thrust-bearings. That is true and it should be so. There are, however, demands for metric thrust-bearings, chiefly in the tool industry, and we are proceeding in the proper way if we standardize so that the user could get the same bearings from one or a half dozen different manufacturers. It is not a question of using the metric system; it is not a question of using the inch system. All designers have a right to use whatever they please. The machine-tool industry uses a great many metric size S. A. E. Standard radial annular-bearings, and metric thrust-bearings.

Speaking from the standards point of view, we desire the reduction of the large number of sizes so that the manufacturers who make metric thrust-bearings will have a minimum standard to work to for the future. Then the man who decides to use metric bearings for one reason or another will have a chance of getting a particular size from one or a half dozen sources.

To those who think that they will be handicapped by another standard of thrust-bearings, I want to say that it will not affect them. It will permit the Standards Committee to bring together the odd sizes, and to do its standardization work properly. It will enable each manufacturer of bearings to make the sizes that are in demand; it will enable the manufacturers of inch thrust-bearings to make as many as they care to make and, likewise, it will enable the manufacturers of metric thrust-bearings to standardize on one set of sizes so that they can supply their demand.

CHAIRMAN JOHNSTON:—Gentlemen, it has been moved and seconded that this subject be referred back to the Division.

[The motion was carried]

PROGRESS REPORTS

In addition to the various recommendations that were discussed and voted on at the meeting of the Standards Committee, two progress reports were presented. One of these reports, that of the Axle and Wheels Division on Differentials, with such discussion as followed its submission, is printed below. The other report on Motor-Truck Cabs that was presented by the Truck Division was printed on p. 547 of the December issue of THE JOURNAL. The remarks made by F. A. Whitten, chairman of the Division, in submitting the report are printed below.

AXLE AND WHEELS DIVISION

DIFFERENTIALS

For some time there has been a feeling that differentials should be standardized. This has resulted in the appointment of a Differential Subdivision of the Axle and Wheels Division of the Society, and a special differential standardization committee in the American Gear Manufacturers Association. The personnel of the two committees is, to a certain extent, over-lapping. This is fortunate as it avoids duplication of work, and insures harmony.

The first part of the differential standardization program embraces two sizes of differential, the inside parts of which have become automatically standardized to a very large extent, through their use over a period of years, by several of the most prominent manufacturers of differentials and axles.

The inside pinion and the bevel gear of the smaller size are an 10-18 tooth combination cut 5/7 pitch. The pinion, as well as substantially the tooth proportion, has been in general use in a wide variety of differentials for some years, so that the standardization of that much should not be difficult. Where the differences do occur, they are chiefly in the matter of the hubs of the gears, and variation in practice as to the method of supporting these gears in the case. Some manufacturers support the gear entirely in the differential spider, others support it entirely in the case, while still others endeavor to get a bearing in both places. In the form under consideration[2], the support is entirely in the spider.

The other size is a 11-20 combination, also of 5/7 pitch. This size likewise is already in very general use, and we should not find it very difficult to reach an agreement upon it.

The report includes the spider for the smaller size, and the corresponding spider for the larger size. These spiders are quite conventional. The bores are ground to provide a seat for the hubs of the side gears.

There are also included in tabular form the principal dimensions of the cases for both sizes of differential. On account of the wide variety of design in general use, it has been found very difficult to arrive at a harmonious and consistent set of dimensions for the case.

There should not be any great difficulty in arriving at a satisfactory conclusion as to the inside dimensions, since these would be made to agree with the corresponding dimensions of the inside parts already discussed.

For the outside dimensions it is necessary to take care of a great variety of practices as to the location of the flange by which the bevel gear is mounted, as well as varying hub-sizes, to accommodate different kinds and sizes of bearing.

In the case of the flange location it was found feasible to establish diameter standards, but no attempt has been made to locate the flange with reference to the center of the differential more than to show a maximum center-dimension. In the matter of hub dimensions, the various bearing manufacturers have been consulted, and average sizes arrived at which were in agreement with their recommendations.

It will be noted that both of these sizes of differential are of the four-pinion type. The two-pinion type of differential has been kept in mind in the course of this work, but it was not thought best to put anything out on that type before the four-pinion type shall have been first more thoroughly established. The two-pinion design would be based on substantially the same inside parts, although it will probably be necessary to modify the designs of the hubs on the side gears when used in two-pinion cases.

What the Subdivision now desires from the membership is a general expression of opinion as to its work thus far. Is it practicable for us to attempt at complete standardization as shown? Does this work meet with sufficient approval to warrant proceeding with other sizes, perhaps both larger and smaller, after these two sizes shall have been completed and adopted?

It is realized that this is a more complete dimensional standardization than is usual in S.A.E. Standards prac-

[2]The tentative recommendation of the Subdivision will be found on p. 124 of the January issue of THE JOURNAL.

tice, but it is the feeling of the Subdivision that it is worthwhile to have this, as a guide, to manufacturers and designers. It is not to be expected that in every case a designer would be able to accept the entire design from end to end. It is the thought, however, that the designer would use the dimensions indicated on the standard to just as great an extent as possible. In that way we would hope, gradually, to reduce the immense number of designs that are now in use, and for which there is no real reason, except that the designer in laying-out his work has no standard from which to start, and in many cases lays-out the proportions very largely to suit his own fancy.

The Subdivision hopes that all members interested in the report will take the designs as submitted which are given in full on p. 124 of the January issue of THE JOURNAL, and lay them out full-size on the drawing-board in their own axles, and from that base their criticisms and suggestions.

THE DISCUSSION

MR. BURNETT:—The object in bringing this report before the meeting is to get discussion on it. It relates to an important subject. We want to have the benefit of as much discussion as possible while the proposed recommendation is being formulated. We will appreciate it if those having any criticisms, suggestions or comments to make on the report will send them to us promptly at the office of the Society.

TRUCK DIVISION

MOTOR-TRUCK CABS

(*December issue of* THE JOURNAL, *p.* 547)

THE DISCUSSION

MR. WHITTEN:—The subject of Motor-Truck Cabs is one on which the Division has done considerable work. It was thought that we had reached a point where a recommendation could be made. We have since found that certain dimensions in the report do not seem to be acceptable, and at a special meeting of the Division yesterday it was decided to withdraw the recommendation for the time being. If possible, cab dimensions will be included also for speed-wagons, making three sizes of cab to cover all requirements from speed-wagons to 6-ton trucks.

ATTENDANCE AT MEETING

The members of the Standards Committee and the Society and the guests in attendance were

Standards Committee Members

Azel Ames
F. W. Andrew
T. L. Lee
B. M. Leece
B. B. Bachman
J. T. R. Bell
R. M. Bird
G. R. Bott
A. K. Brumbaugh
H. E. Brunner
Earle Buckingham
T. V. Buckwalter
J. S. Burdick
R. S. Burnett
R. J. Burrows
C. C. Carlton
E. R. Carter
D. F. Chambers
W. A. Chryst
E. L. Clark
C. F. Clarkson
A. L. Clayden
L. W. Close
J. Coapman
W. F. Cole
P. J. Dasey
B. H. DeLong
H. E. Figgie
J. B. Fisher
Bruce Ford
C. B. Franklin
J. R. Freeman
E. S. Fretz
D. E. Gamble
C. F. Gilchrist
F. P. Gilligan
W. E. Gossling
F. W. Gurney
W. S. Haggott
C. A. B. Halvorson, Jr.
A. W. Herrington
W. H. Herschel
S. P. Hess
C. E. Heywood
W. E. Holland
M. C. Horine
L. S. Horner
H. S. Jandus
E. J. Janitzky
E. A. Johnston
L. S. Keilholtz
H. B. Knap
F. C. Kroeger
G. L. Lavery
A. D. T. Libby
F. E. McCleary
W. A. McKay
H. R. McMahon
K. G. Mackenzie
C. M. Manly
G. J. Mercer
C. A. Michel
A. H. Miller
G. L. Miller
F. L. Morse
H. C. Mougey
C. T. Myers
F. F. Murray
A. J. Neerken
I. M. Noble
G. L. Norris
Leonard Ochtman, Jr.
W. C. Peterson
W. M. Petty
W. H. Phillips
H. M. Pierce
H. S. Pierce
H. L. Pope
L. C. Porter
W. B. Price
W. D. Reese
O. J. Rohde
C. B. Rose
J. L. Rupp
C. F. W. Rys
A. J. Scaife
A. W. Scarratt
M. H. Schmid
Louis Schwitzer
J. W. Stack
J. C. Stearns
L. M. Stellmann
W. R. Strickland
Alex Taub
G. W. Vinal
Edward Wallace
J. M. Watson
E. W. Weaver
W. R. Webster
E. E. Wemp
J. A. White
F. A. Whitten
F. G. Whittington
Ernest Wooler
O. W. Young

Society Members and Guests

C. D. Addams
C. M. Ahlene
C. E. Banta
George Bell
Norman Bell
C. M. Billings
B. H. Blair
A. B. Breeze
W. J. Bryan
N. B. Burkness
Henry Chandler
H. E. Clay
K. H. Condit
R. C. Cornforth
G. H. Cottrell
R. H. Cunningham
M. P. Davie
P. H. Davis
W. H. Eiseman
M. P. Ferguson
T. B. Fordham
C. K. Francis
D. J. Gilbert
G. Walker Gilmer, Jr.
A. N. Goodfellow
C. S. Grove, 3rd
F. A. Groves
G. A. Hancock
J. E. Houser
J. H. Hunt
R. K. Jack
W. P. Kendall
G. W. Klinger
B. Kulmow
R. P. Lansing
A. J. Lavoie
L. C. Marshall
R. L. Maxen
E. V. Pannell
R. E. Plimpton
J. R. Reyburn
C. W. Rice
O. C. Rohde
R. F. Russell
J. E. Schipper
J. M. Schoonmaker, Jr.
E. M. Schultheis
R. A. Shailer
Arthur A. Skinner
F. S. Slocum
F. G. Smith
W. Stacker
G. A. Ungar
M. P. Whitney
H. M. Williams
A. D. Wilt, Jr.
C. H. Young

SOCIETY MEETINGS

THE ANNUAL MEETING

Registration Large and Great Interest Displayed by Those Who Attended

Go-getters are men who know what they want and then go and get it. The Annual Meeting was a meeting of go-getters. Attendance at this meeting constitutes star performance in automotive go-getting. There were more than 600 star performers this time. They knew they wanted additional automotive engineering and commercial knowledge, to secure the maximum number of contacts with the good, live, uptodate, automotive data that were presented, to meet other go-getters and to talk things over. So, they came and got all these desirable results, and more! They got inspiration for future effort; inspiration is all that keeps any of us in the go-getting class. New ideals, new ideas, new plans and purposes are continuously necessary to our existence and to our progress and, since they come to us so seldom, most often we must go and get them. Those who seek, will find. In this instance, as in the many previous ones, each man who attended was well rewarded.

Beginning with the usual all-day session of the Standards Committee, on Jan. 9, the results of which are annually so important and so far-reaching, the program of the week, replete with engineering and human interest, was carried through whole-heartedly and successfully to its conclusion on Jan. 12, following the presentation of the unusually complete papers and discussion that constituted the session devoted to engine cooling.

The business session held on the morning of Jan. 10 was of more than ordinary interest, a summary of the work of the past year and an outline of the Society's plans for the year to come being presented. The following outline of what transpired as the program of the 1923 Annual Meeting unfolded is an illuminating record of automotive progress and an earnest of greater achievement yet to come.

MEMBERSHIP CONDITIONS SATISFACTORY

Slightly More Names on Roll Than Last Year

The report of the Membership Committee, which was presented by L. C. Hill in the absence of Chairman Lon R. Smith, is given below.

Membership Department Summary

On Dec. 31, 1922, there were 5135 members of the Society, excluding Enrolled Students and including Service Members, Foreign Members, Members, Associates, Juniors, Affiliate Members and Affiliate Member Representatives. The addition of 214 Enrolled Students bring the overall total to 5349, 32 more than last year.

Service Members, Foreign Members and Affiliate Member Representatives show an increase of 23, 14 and 9 respectively. On the contrary, Members, Associates, Juniors, and Affiliate Members show a decline of 50, 39, 47 and 2. The greatest numerical increase, 124, is in Enrolled Students, contrasted with a decrease of 92 for all the other grades combined.

The above are net figures showing final totals after the subtraction of the following: Deceased, 12; Resigned in good standing, 166; Dropped as delinquents, 480; and Cancelled, 22. The total deduction is, therefore, 680.

CAMPAIGNS

In the earlier part of the year, the Society conducted a campaign to enroll more of the major executives of the industry. We have added five of the most prominent in the past year.

We are also conducting a campaign in the passenger-car field, as an investigation showed surprisingly few passenger-car men on the Society's roster, relative to the total membership.

The Society should be able to increase the number of production men on the rolls considerably during the coming year. The national Production Meeting held in Detroit on Oct. 26 and 27 was attended by 248 non-members who should be good prospects, especially as the Detroit Section is planning a number of production meetings to develop the interest aroused by the first meeting.

Grade	Dec. 31, 1920	Dec. 31, 1921	Dec. 31, 1922
Service Members	18	65	88
Foreign Members	50	67	81
Members	2,706	2,723	2,673
Associates	1,495	1,509	1,470
Juniors	692	671	624
Affiliate Members	112	107	105
Affiliate Member Representatives	117	85	94
	5,190	5,227	5,135
Enrolled Students	41	90	214
	5,231	5,317	5,349

ACTION ON RECOMMENDED STANDARDS

Practically All Division Reports Approved as Submitted

At the meeting of the Standards Committee on Tuesday, Jan. 9, 17 Divisions submitted reports for Standards Committee action, 30 recommendations being approved in original or amended form, and one recommendation being referred back for further consideration to the Division that formulated it. With the exception of the report of the Chain Division and the recommendation of the Lighting Division on Tail-Lamp Illumination, the reports were printed in the December issue of THE JOURNAL.

The Ball and Roller Bearings Division report on Metric-Type Thrust Ball Bearings caused a considerable amount of discussion, principally with regard to the policy in American standardization of setting up standards in the metric system. Discussion indicated rather an even division of opinion, and it was finally voted to refer this report back to the Division.

The Chain Division report, which was not completed in time for publication in the December issue of THE JOURNAL, consisted of several parts relating to the mini-

mum breaking-strengths of roller-chains and to standard sprocket tooth-forms and cutters for them. The recommendations involve revisions of the present standards as published in the S.A.E. HANDBOOK. The report, the presentation of which was accompanied by lantern-slides illustrating the application of the recommendations, was approved.

The report of the Lighting Division on Tail-Lamp Illumination was submitted at the meeting in mimeographed form, it having been formulated too late for inclusion in the December issue of THE JOURNAL. The recommendation was based on joint action of the Illuminating Engineering Society and the Society, largely at the request of one of the New England States, because of recent legislation enacted relating to the approval of automobile tail-lamps and registration-plate brackets. It was felt that it is important to have standard specifications in this connection inasmuch as many of the States, which are considering relevant legislation, can probably be favorably influenced toward using a standard specification. It is important to note that the Society has not gone further than to participate in the preparation of what the Division considers a suitable technical specification for testing tail-lamps and tail-lamp illumination. The Division's report was approved as presented.

The report of the Lubricants Division on standard specifications for Crankcase Lubricating Oils was discussed at considerable length with regard to the explanatory grade-names used in conjunction with the proposed specification numbers for the several grades of oil. Modifications of the explanatory grade-names were suggested, but were not generally favored. The report was finally approved for adoption as S.A.E. Recommended Practice, with the omission of the explanatory grade-names.

The Truck Division recommendation for Motor-Truck Cabs was withdrawn as a recommendation for adoption and presented as a progress report only, as a result of recent action taken by the Division.

A progress report was submitted also by the Axle and Wheels Division, on Differential Gears, lantern-slides being shown of the tentative recommendation as printed in the article on Current Standardization Work in the January issue of THE JOURNAL.

The detailed discussions of the Division reports, together with the complete recommendations submitted for action subsequent to the publication of the December issue of THE JOURNAL, are printed elsewhere in this issue. A mail vote on the final adoption of the reports will close on March 12. All of the Society Members who are entitled to vote will be furnished letter-ballots in accordance with the regulations governing the Standards Committee.

GREATER INTEREST IN MEETINGS SHOWN

More and Better Papers Offered for Presentation — Plans for the Future

C. F. Scott, chairman of the Meetings Committee, reported that seven Society meetings were held during the year 1922 as compared with five in the previous year. The Production Meeting was a new development and, he hoped, the beginning of like meetings. This meeting was highly successful, the attendance at the technical sessions being as large as that of some of the technical sessions at the Annual and Semi-Annual Meetings of the Society. The general character of the technical papers presented at the meetings he stated was better than before; and the Committee was in receipt of numerous offers of papers for presentation at the meetings of the Society.

A regional meeting is to be held at Cleveland in April. The subject will be transportation, the plan of conducting the meeting being along the same general lines as that for the Detroit Production Meeting, with technical sessions in the morning and visits to factories in the afternoon.

The time and place of the holding of the 1923 Summer Meeting have not been determined as yet since the main factor entering into the selection of places for the Summer Meetings of the Society has become the recreational facilities available rather than central location.

SOCIETY OFFICERS FOR 1923 ELECTED

A Greater Number of Ballots Cast Than at Any Previous Election

Immediately after the convening of the business session on Wednesday morning, Jan. 10, President B. B. Bachman, who was in the chair, appointed L. S. Keilholtz, J. A. Anglada and C. E. Heywood as tellers of the election of officers to serve during this administrative year and of councilors to serve during 1923 and 1924.

After canvassing the ballots the tellers reported that 952 ballots had been cast, 32 of these being void. The total count on the election, with scattering votes, was as follows:

President

H. W. Alden	917

First Vice-President

H. M. Crane	917

Second Vice-President Representing Motor-Car Engineering

A. F. Masury	916

Second Vice-President Representing Aviation Engineering

E. P. Warner	915

Second Vice-President Representing Tractor Engineering

A. W. Scarratt	917

Second Vice-President Representing Marine Engineering

E. J. Hall	917

Second Vice-President Representing Stationary Internal-Combustion Engineering

L. W. Witry	916

For Members of the Council
(To serve for 2 years)

A. J. Scaife	920
W. A. Chryst	917
F. W. Gurney	917

For Member of the Council
(To serve for 1 year)

H. M. Swetland	919

For Treasurer

C. B. Whittelsey	920

SOCIETY'S FINANCIAL CONDITION SOUND

Deficit for 1922—Income and Expense Approximately Equal Now

The Treasurer's Report was presented in the form of a brief summary, which is given below, by General Manager Clarkson in the absence of the Treasurer, C. B. Whittelsey, who was unable to attend on account of illness. This report, which was printed in the January issue of THE JOURNAL, indicates a sound financial condition.

The annual audits of Rankin & Co., public accountants, list the assets of the Society at approxi-

mately $154,000 on Sept. 30, 1922, and $156,000 on the same date of 1921.

These were offset by debts of approximately $31,000 in 1922 and $17,000 in 1921, leaving an unexpended reserve of approximately $122,000 at the close of the last fiscal year, which was about $15,000 less than on Sept. 30, 1921.

The Society's income for the fiscal period ended Sept. 30, 1922, was in round numbers, $248,000 and for the preceding fiscal period $243,000.

The expense for the same period was $263,000 in 1922 and $233,000 in 1921, leaving a deficit in 1922 of about $15,000 as compared to unexpended income of about $10,000 in 1921.

On Sept. 30, 1922, the Society owned Government and railroad bonds having a par value of $78,000 and a market value of $76,000. Ten thousand dollars has been invested in securities since Sept. 30, bringing the total up to $88,000.

There has been very little relative change in the status of the Society's finances since Oct. 1. The income for the first three months of this fiscal year was approximately the same as the expense. We hope to keep the expense within the income figures throughout the year and at least to be able to show no loss at the end of the current fiscal period.

PROBLEMS OF THE SECTIONS

Section Dues, Appropriations and Affiliation with Other Local Bodies Discussed

A. K. Brumbaugh, Chairman of the Sections Committee, presented the following report:

No new Sections were formed in 1922, but the ones in existence at the start of the year have each carried through a series of valuable Sections Meetings. A better appreciation of the value of Sections Meetings has been evidenced by the members and the growing importance of Sections as an activity of the Society has been appreciated in a greater degree by the Council. A number of important problems, many of them fundamental, have arisen during the year. All of these have been carefully studied by the Committee and referred to the Council with definite recommendations as to their solution.

The suggestion that Section dues should be waived has received support from several sources during the year. The Sections Committee studied the matter with care and voted to support the present practice of charging $5 for annual dues in each of the Sections. The major part of the administrative expense of the Sections is now borne by the national treasury. It is believed unfair to have all Sections' expenses covered by national dues, for the reason that a large percentage of the members in the Society are never able to enjoy the privileges of Section membership, due to their residence in cities that are not served by the local Sections. The most equitable solution seems to be to ask the local members to pay dues in the Sections for the privilege of attending Sections Meetings.

Having supported the charging of Sections dues, the Committee was faced with the problem of placing some tangible value on membership in the Sections so that the officers of the Sections would find it easier to collect dues. It was found that many members of the Society continued to enjoy the advantages of attending Sections Meetings after having refused to pay dues to the Section. This practice, logically unfair, resulted in the Metropolitan Section charging admission to its meetings for Society members who were not members of the Section. The Detroit Section instituted the practice of asking each member for his Section membership-card at the door of the meeting and insisting that he request one of the members of the Section to invite him into the meeting as a guest, if he was not a member of the Section himself. The officers of the Metropolitan Section seem to be agreed that their scheme is working satisfactorily. The Detroit Section found that its practice resulted in a number of additional members joining the Section. The Council now has this whole matter, outlined above, under consideration.

Study of the financial reports of the Sections on Sept. 1 showed that the past methods of appropriating money from the National Society to each of the Section treasuries had not been equitable. Some of the smaller Sections were given more money than they needed; and one or two of the larger Sections were given insufficient funds and found it necessary to raise money by subscription to offset their deficits. After careful study, the Sections Committees recommended to the Council that future appropriations to the Sections be made according to the following formula: A basic appropriation of $250.00 to each Section; $1.00 for each member of the Society residing within the Section territory as designated by the Council; and $2.00 for each member of the Section who had paid his Section dues by April 1.

Checking the appropriation as computed by this formula against the funds claimed to be needed by each of the Section treasurers, it was found that the national appropriation, combined with the local Section dues, would suffice to take care of the expenditures of all of the Sections. This formula plan has been approved by the Council.

During 1922 a number of the Sections were asked to amalgamate with other Sections of national engineering societies in what are known as local engineering clubs or associations. The object in each case was to have the clerical work of all of the associations taken care of by a single paid secretary with a consequent reduction in overhead to each of the Sections. In each case these local engineering associations have established club-rooms for the holding of engineering meetings. The Buffalo, the Cleveland and the Mid-West Sections have joined such associations. The Detroit Section decided against such an affiliation because of the belief that the Section was sufficiently large to carry its own overhead and that any affiliation would result in diminishing of the Section prestige. The Sections Committee has regarded favorably any affiliation with local engineering associations, provided the identity of the Society were not lost or interest in its activities as a Society diminished.

Requests have been received from at least two of the Sections for the approval of some form of local membership in the Section for men who are not members of the national Society. It will be recalled that at one time the Sections had such a form of affiliation, known as Section Associateship. This form was discontinued because its privileges were often abused by men who felt that they enjoyed the same privileges in the Society as its members. A reestablishment of this practice would be replete with problems. It has been suggested that such local Associates should not be extended any privilege other than attendance at local Section meetings. THE JOURNAL would not be mailed to them and they could not attend national meetings of the Society without payment of the customary fees for non-members. The Washington and the Detroit Sections feel that there are a number of men in their territories who would contribute to their financial support by paying for the privilege of attending the local meetings. The interest of these men in the Society is purely a local one; they seldom attend national meetings; in many cases they are young men unable to pay the more costly dues to the national Society. No decision has been reached in this matter, for it is of recent origin; however, the 1923 Sections Committee will recommend some definite action to the Council.

In general, with few exceptions, the officers of the Sections during the year 1922 have shown praiseworthy devotion to their responsibilities. The character of pa-

pers presented at Sections meetings has constantly improved; and authors must have something meritorious to present before they are accorded the privilege of addressing Sections meetings. Service to the Sections on the part of the Society staff has been broadened. Assistance is given in the selection of meetings topics and speakers and in soliciting Section membership. Publicity service on Sections meetings, in THE JOURNAL, the trade press and the newspapers, has been extended by the staff organization to the Section secretaries. A Sections Bulletin has been created for the purpose of circulating items of interest among the Sections officers and committeemen periodically. The Sections meetings are being reported more fuly in THE JOURNAL of the Society, the salient points in the papers and discussion being stated.

The Sections Committee of 1922 has been impressed with an increasing importance of the Sections as outposts of the national Society. Sections meetings will increase in value and prestige until they are close rivals of the national and regional meetings of the Society. It will be considered as much of an honor to present a paper before a meeting of a Section as before one of the national meetings. Section activities will develop a stronger local interest in the affairs of the national Society and result in the strengthening of its position in general.

WHAT CAUSES WHEELS TO WABBLE

Ball-and-Socket Joints and Elimination of Castering Suggested as Remedies

Following the Business Session, the paper by Herbert Chase, entitled Critical Study of Modern Automotive-Vehicle Steering-Systems, was presented by the author and discussed. In presenting this paper Mr. Chase pointed out that steering-systems as a whole have changed but little for many years and inasmuch as the conventional layout has operated with reasonable satisfaction in most cases it has been given relatively little attention. Among the common faults of the steering-system is the excessive effort required in its normal operation, the primary causes of hard steering being friction and faulty design of the system. The use of anti-friction bearings of both the ball and the roller type in the steering-gear to take thrust and also radial loads was commented on, after a brief discussion of the causes of hard steering, such as incorrect location of steering-arms and distortion of the various parts of the steering system, under either the load of the vehicle or that imposed by the steering operations, the weight of the front wheels of the vehicles and the length of the moment-arms. Mr. Chase then took up the question of the angular position of the knuckle-pivot and the locating of the knuckle-pivot as close to the central plane of the wheel as is reasonable without involving unnecessary expense.

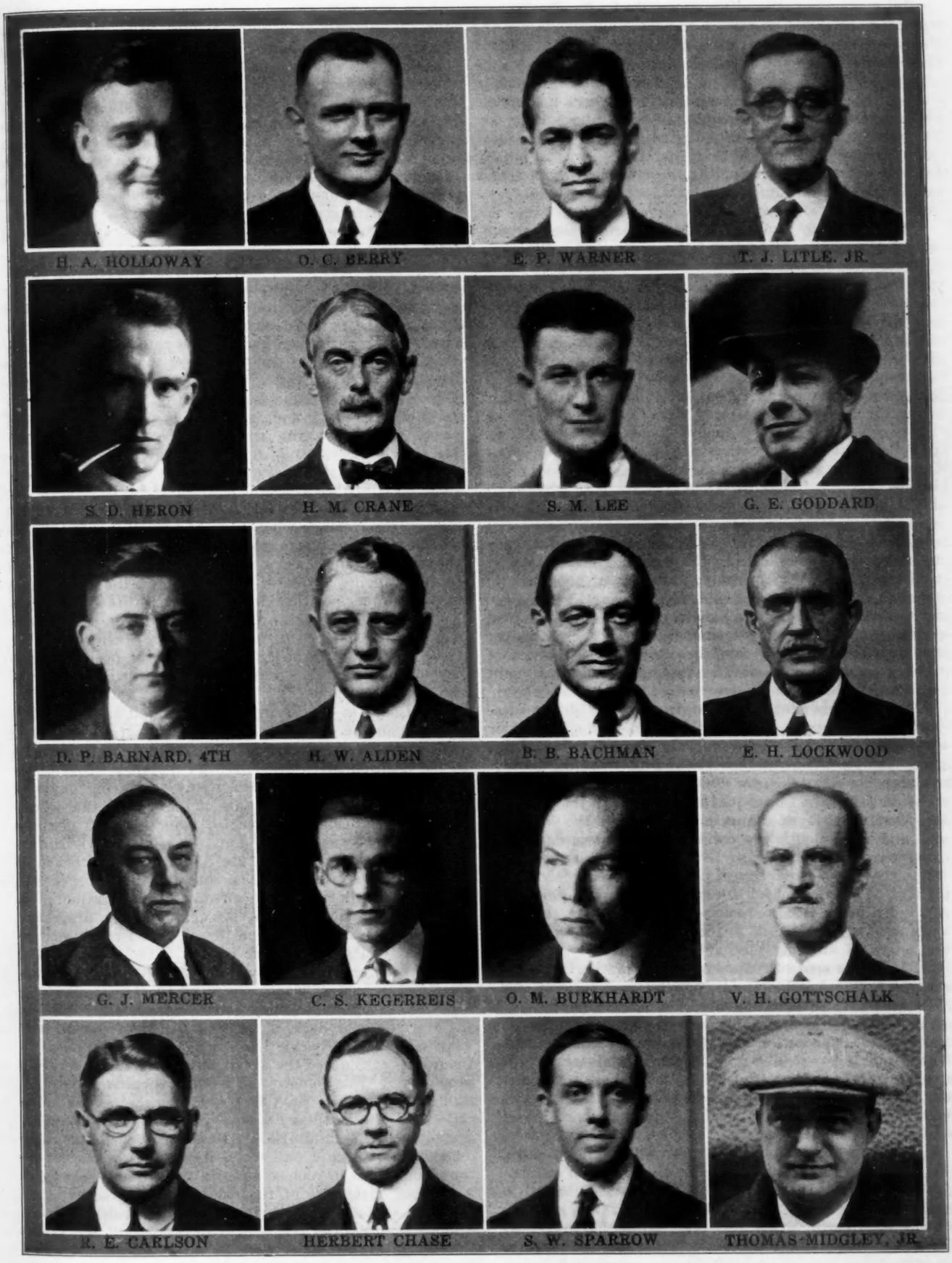
One of the most common faults of the steering system and one whose causes are least understood, said Mr. Chase, is that of wheel wabble, which is the periodic oscillation in the angular position of the wheel and the axle spindle about the knuckle-pivot, the result being that the wheel follows a course which deviates alternately to the right and the left of a straight line. The three primary causes of wheel wabble according to Mr. Chase are (*a*) unstable equilibrium of wheels carried on knuckles with inclined pivots, (*b*) faulty layout of drag-links with reference to the springs and (*c*) a lack of balance or failure of the wheels to run true. In discussing the question of drag-link location Mr. Chase said that the best layout is the one which causes the least motion at the wheel spindle about the knuckle-pivot when the axle is moved under the influence of the spring action.

In opening the discussion of the paper, Cornelius T. Myers emphasized the importance of brakes and steering mechanisms from the standpoint of safety. He thought that a feature of major importance in the layout of the steering mechanism is the relation of the travel of the ball on the steering-knuckle arm when under the influence of the spring vibration to the ball on the arm of the steering-gear itself. The arc followed by the spring-seat and that described by the outer ball in the drag-link should coincide as closely as possible for a distance equal to the usual movement of the springs. The tendency to wabble is due largely to the varying amounts by which these two paths diverge in any particular steering layout.

Another point brought out by Mr. Myers was that the wabbling seems to be greatest when there is a perceptible amount of wear in the steering-pivot bushings, the wheel bearings, the tie-rod connections and similar parts. When successive bumps or depressions in the road surface synchronize with the taking up and giving out of the total amount of wear or slack, the wabbling seems to be most severe and somewhat analogous to snapping a whip or more directly to snapping a chain in which the links are long in proportion to their width.

Unbalanced forces set up in the front wheels by the weight of the tire-valves and adjacent parts also in his opinion exert an influence on wabbling; he is still experimenting upon this point. As the wheel spindles are not horizontal these unbalanced weights move toward and away from the chassis as the wheels revolve, it being apparent that when the position of the valve in the left wheel bears a certain relation to the position of the valve in the right wheel the forces set up as these valves revolve tend to counteract each other and balance, although on the other hand the relative location of the two valves might be such that two forces would be additive. In support of this he mentioned cases where wabbling had started on comparatively smooth concrete roads when the car was driven in one direction but no wabbling had occurred when the car was turned and driven over the same stretch in the opposite direction at the same speed. When this wabbling occurred on smooth hard roads it usually took place at nearly double the speed at which it took place on rough roads.

In his opinion the conditions under which violent wabbling takes place depend upon a number of different factors such as the steering layout, the inequalities of the road, the vibration period of the springs, the speed of the car, the weight of the front end of the car, the moment of inertia about the vertical axis, the tire inflation and the wear and looseness of the front axle and the steering-gear parts. While often minor changes of one kind or another apparently cure the trouble, it is latent if the steering mechanism is not correctly laid-out, and will reappear under somewhat different conditions than at first. One way to minimize wabbling is to turn the car steadily and not too sharply to one side or the other. In this connection it was pointed out that it is best as a rule to drive on the right side of a crowned road so that a little left-arm pull on the steering-wheel must be exerted continually to maintain a straight course. In this way the slack is taken out of the loose steering connections and any wabbling due to looseness only obviated, while a further turning toward the left or the crown of the road will take any slack produced when wabbling is started by impressed vibration from road bumps and often damp out the wabble before it becomes severe.


H. A. HOLLOWAY
O. C. BERRY
E. P. WARNER
T. J. LITLE, JR.
S. D. HERON
H. M. CRANE
S. M. LEE
G. E. GODDARD
D. P. BARNARD, 4TH
H. W. ALDEN
B. B. BACHMAN
E. H. LOCKWOOD
G. J. MERCER
C. S. KEGERREIS
O. M. BURKHARDT
V. H. GOTTSCHALK
R. E. CARLSON
HERBERT CHASE
S. W. SPARROW
THOMAS MIDGLEY, JR.

In continuing the discussion, Prof. E. P. Warner pointed out that looseness in the steering-gear is not the only cause of wabble, since a motorcycle with a rigid steering-gear is subject to this phenomenon, as is also the bicycle. Mention was also made of the British scooter on which the operator stood on a platform where the vehicle became entirely unmanageable at speeds above 12 m.p.h. In connection with the wabbling of motorcycles and bicycles it was pointed out that the wabble was cured by changing the curvature of the fork, which was the same thing as eliminating the castering effect in an automobile.

M. C. Horine took exception to Mr. Chase's recommendation that anti-friction bearing be used in steering-gears since, he stated, they tend to produce hard steering. He did not agree with the use of a center-point steering arrangement, saying that it is difficult to operate easily at low speeds as the action is that of grinding rather than rolling the wheel about a point. The toeing-in or foregather of the wheels is a problem of the automobile industry only, as apparently the builders of horse-drawn vehicles solved it satisfactorily in their field some time ago. One cause of wheel wabble, Mr. Horine believes, is the use of standard front-axles for vehicles of different wheelbases, thus producing a varying angularity of the steering-arm. He took exception to Mr. Myers' statement regarding the ranking of brakes before the steering mechanism from the viewpoint of safety, stating that personally he would much prefer to be able to steer a vehicle and trust to being able to stop it, than to have means for stopping the vehicle and not be able to steer it. He also mentioned the use of the straight fork on a certain make of motorcycle about 15 years ago as a successful means for curing the wheel-wabble that caused trouble. In this arrangement the center line of the fork was extended to intersect the axle, instead of coming behind it and intersecting the road at a point in front of the point of tire contact.

O. A. Malychevitch said that irreversibility is an important factor in steering and mentioned the Schneider steering-mechanism employed on the Paris omnibuses as a good example of mechanism in which no wabbling occurs.

Exception was taken by O. M. Burkhardt to the statement made by Mr. Chase that road shocks in the plane of the wheel have a minimum moment about the knuckle-axis and consequently are transmitted in a less degree to other parts of the steering mechanism. He stated that while the moment is less it is transmitted more completely. The amount of foregather can be determined easily by geometric methods. In his opinion, bearing loads are very important in the effect that they exert on the action of steering mechanism.

A. J. Scaife spoke of the experience of the White Co. with a ball-and-socket joint on the steering-rod end. He stated that after being used for some time the ball became oval and the steering was cramped, thus leading the White organization to abandon this construction. Wheel-wabble is extreme with loose mechanism; he cited a case where a taper wedge inserted between the spring and the spring perch on the front axle had eliminated the wabbling, whereas taking up the joints had not proved successful.

L. H. Pomeroy spoke of the possibilities of shackling the spring at the front end as in the De Dion car and also in the buses used by the Fifth Avenue Coach Co. in New York City. He pointed out that the angle at which the steering-arms and their projection intersect the axis of the chassis exert a considerable influence on wheel-wabble. In support of this he mentioned a case where the projections of the steering-arms intersected the chassis axis at a point distant from the front axle an amount equal to 56 per cent of the length of the wheelbase and the wheels wabbled very badly, while by changing this position of intersection to 62½ per cent of the wheelbase satisfactory results were obtained. In his opinion wheel wabble results from two or three contributary causes and not from one alone. He cited a case where a car that wabbled badly when equipped with demountable wheels and rims was rendered entirely free from this phenomenon by the use of standard wheel equipment. Another cause of wheel wabble was the maintaining of an unnecessarily tight grip on the steering-wheel by the driver.

Dr. H. C. Dickinson discussed the question of wheel-wabble from the viewpoint of the application of the fundamental laws of harmonic vibrations. He pointed out that the periodic wabble of the wheel must follow the law of a pendulum and tend to return. When a system is forced out of position there is of course a force tending to restore it to its normal state but the damping exerted by friction is not greater than this force of restitution. In his opinion there would be no wabble if there was no castering action and a completely irreversible steering gear would not wabble. Wabble would likewise be absent if friction in the system were greater than the force applied to maintain the vibration of the system. In support of Mr. Pomeroy's theory that a hard grip of the steering-wheel may be responsible for wheel-wabble, Dr. Dickinson pointed out that such a grip of the wheel would induce wabble since the physiological reaction applies a greater force to return the road wheels to their proper position than that which throws them out. Another cure for wheel-wabble is to provide in the system for a resistance to motion that is greater than the force tending to throw the wheels out of position. Abnormal sidesway also reinforces the normal tendency of the wheel to wabble.

Mr. Chase in concluding the discussion stated that in his opinion the castering angle does affect wabble, thus taking exception to Mr. Myers' statement. In support of his position Mr. Chase cited an instance where a car was absolutely out of control with a castering angle of 10 deg., while changing this angle cured the wheel-wabble. The usual angle varied from 1½ to 3 deg., although 6 deg. was a maximum. In reply to Mr. Horine Mr. Chase stated that the use of anti-friction bearings shows that they are practical and that the proper size of bearing will reduce the effects of corrugation mentioned by Mr. Horine. The laying-out of the drag-links is a geometrical problem and there are a number of layouts that will operate more or less satisfactorily. The drag-link arrangement shown in the paper in which the steering mechanism was in front of the front axle is in Mr. Chase's opinion a very good arrangement. Placing the steering-gear back of the axle would be better if it were possible to shackle the spring at the rear end, although he considered the arrangement of front shackling proposed by Mr. Pomeroy as being desirable under certain conditions. In Mr. Chase's opinion the proper lubrication of the ball-and-socket joint in the steering-mechanism will minimize the wear and it is no more difficult to replace a ball when it becomes worn out-of-round than it is to replace a pin in the pin-and-yoke type. A further advantage of the ball-and-socket construction is that a socket with a spring-backing provided for continuous taking-up of the wear. In conclusion Mr. Chase stated that even if there were no castering wabble would occur.

COMMERCIAL-AIRPLANE DESIGN

How Economical, Safe, Speedy and Comfortable Machines Should Be Built

At the aeronautic session held on the evening of Jan. 9, Prof. E. P. Warner discussed commercial airplane design in general terms, under the main divisions of economy, safety, speed and comfort, in presenting his paper on the Design of Commercial Airplanes. He mentioned possible reductions of first cost by designing for long life and reliability, the effect of the former on the depreciation allowance being obviously advantageous. Safety was stated to be dependent upon reliability, structural strength, stability, control, fire prevention and the reduction of the risk of injury to passengers in the event of a crash. Minimizing the bad results of a crash were considered suggestively. He believes that, since speed is governed almost solely by the ratio of wing loading to power loading, speed will always be kept as low as possible without any loss of business to competing companies. Among other desirable measures to secure comfort, he specified adequate ventilation and the elimination of noise.

CREATING A DESIRE TO FLY

An Outline of a Possible Public Commercial-Airplane Demonstration

The second paper at the aeronautic session, by C. G. Peterson, presented immediate possibilities in the way of commercial-airplane service. Stating that the heretofore impossible barriers to commercial aviation have been costs and the lack of desire of the public to fly often, or to fly at all, Mr. Peterson proposed that the public, which must constitute the market for airplanes on a commercial basis, be educated by a demonstration of safe and reliable, pay-load airplane-service extended over an indefinite period, and outlined a plane that includes the surmounting of cost deterrents.

He marshaled arguments and statistics to show that such a public demonstration can be made by a proper and adequate equipment, operation and maintenance of the United States Aerial Mail Service, since it has been demonstrated already by this service that mail can be carried safely by air throughout hard Northern winter weather.

His statistics include consideration of the present volume of mail, special-delivery-letter and parcel or package-carrying possibilities as revenue producers, and necessary postal rates.

An extensive estimate of the cost of equipping and operating a night-flying line between New York City and Chicago, based on present equipment, was presented. The author expressed the belief that passenger traffic will follow, without any solicitation on the part of the operators, just as soon as the public realized that the mail airplanes fly safely and on time.

COMPETITIVE BIDS HURT AVIATION

Does Government Procedure Discourage Rather Than Encourage Development?

In his aeronautic-session paper on The Development and Construction of Military Airplanes in Peacetime, F. H. Russell considered the reconstruction period following the war and the conditions prevailing on Jan. 1, 1923. Present conditions were stated to be far from satisfactory because of Government competition with the aeronautic industry and lack of appreciation of both the necessity for and the requirements of a healthy industry.

The solutions proposed by the author are (*a*) that Government agencies inspire and direct the industry in the development of the types desired and the peacetime supply thereof, through the operation of equipment; and (*b*) that airplanes of one type such as a type of engine or automobile, be considered as proprietary and not subject to open competitive bidding.

Mr. Russell summarized the current situation in regard to conditions most detrimental to progress. His view of the peacetime problem of the Government engineer is that it involves first the selection of those types of planes which are required for actual military training and operations; and, second, the guidance and support of the industry toward the development of such designs, having in mind constantly that the airplane developed must not only be satisfactory for the service desired, but be designed in detail so as to be suitable for quantity production.

With regard to civilian aircraft organizations, the author stated that they must consist, not only of a capable group of creative engineers, but also of men trained and experienced in manufacturing. The physical facilities should include wind-tunnels and aero dynamic, physical and chemical laboratories, and also the latest types of production machinery. Any separation of engineering from production, such as is found in connection with types of airplane developed by small engineering units, or production without adequate creative engineering, Mr. Russell believes, is bound to result disastrously. The two must go together. In his opinion, the Government should establish a policy whereby, under proprietary orders, a company can specialize in the development of one design or class of aircraft, build it continually in small quantities, and improve it. He stated that such a civilian organization should be required to furnish standardized specifications, blueprints, bills of material and the like which, in time of national emergency, could at once be placed in the hands of executives controlling factories outside of the industry for quantity production.

SAFE FLYING A PRESENT PUBLIC ASSET

Regular Aerial Transportation of Passengers Over Water Accomplished

A widely prevalent barrier to the success of commercial aviation was stated by Harry Bruno, in his aeronautic-session paper, to be the difficulty of convincing the public that we have successful commercial aviation now. As a representative of an aerial-transportation company now maintaining regular service over water, he believes this country to be ahead of Europe in regard to overwater aerial-transport. His company maintains in service 27 flying-boats that have, in the past 3 years, made 2125 flights, carried 9107 passengers and flown 739,047 passenger miles without any injuries or deaths resulting.

He said that the actual cost of gasoline and oil, maintenance and depreciation is small compared with the cost of persuading the public to come to the starting-points of the different routes, that the public does not demand a speed of more than from 65 to 90 m.p.h. and that the

ordinary individual cannot comprehend a speed as great as 125 m.p.h. His belief is that the public is favorably inclined toward flying, and that successful operation, as in the case of the 700-mile mail-and-passenger service now conducted in South America, will eventually cause a change in public sentiment. In further support of this belief, he said that during the first month of the flying service between Cleveland and Detroit, a 90-min. trip, the passengers were mostly women and children; but that during the second month of operation the passengers were mostly business-men.

A further possibility in the development of commercial aviation was stated to be service as an adjunct to railroad operation.

GENERAL COMMENT ON AERONAUTICS

Some Interesting Views Expressed by Members in Attendance

C. M. Manly was a leader in the discussion at the aeronautic session. He emphasized the need of selling the idea of commercial aviation to the public, inclusive of the farmer and other people in the rural districts, and made suggestive comment upon the aeronautic situation in general.

R. R. Blythe spoke of the inconveniences incident to starting on an aerial trip and of the necessity of minimizing them in line with encouraging passengers to travel in this way. He believes that regularly operated aerial express-lines would be most helpful in securing public confidence in aeronautics.

C. D. Hanscom discussed postal rates in connection with Mr. Peterson's paper and believed that a letter could be carried by aerial mail between New York City and Chicago for 0.8 cents.

Archibald Black discussed Professor Warner's statement that

> At present it seems impracticable to realize a commercial speed of more than 85 m.p.h. on lines running without subsidy, as the costs of operation at higher velocities than that become prohibitive.

Mr. Black thinks that a speed of 105 or 110 m.p.h. can be maintained without increase in the cost.

Edward Shildhauer suggested a lighter-than-air aircraft service as a backbone between such points as New York City and Chicago, supplemented by airplane service radiating from such terminals; the main-line flying to be done at night, with arrivals at dawn, and the airplane service to start at dawn, with return-trips each afternoon.

Other expressions by representative men in attendance included a suggestion that an appeal for commercial aviation be made to the sporting blood of the public, that unusual markets for aircraft service can be unearthed, such as patrol and photographic service, and that difficulties incident to aircraft flying in fog and at night be overcome.

MEASURING MOTOR-FUEL VOLATILITY

Further Data on the Initial-Condensation Temperatures of Various Mixtures

The first paper presented at the fuel session on Thursday afternoon, Jan. 11, was by R. E. Wilson and D. P. Barnard, 4th. In this paper, which was presented by Mr. Barnard, the method for measuring the dew-points or initial-condensation temperatures of motor-fuels when mixed with air in various proportions as outlined in an article by these authors that appeared in the November, 1921, issue of THE JOURNAL was extended to include a larger number of fuels. In the earlier article only three fuels were considered, while in the paper presented at this session the results of an investigation of 14 fuels ranging in volatility from the lightest aviation gasoline to a rather high-boiling commercial kerosene were given. Much of this work was done in connection with the co-operative fuel-research program conducted jointly at the Bureau of Standards by the American Petroleum Institute and the Society. The paper describes certain modifications and improvements in the method previously described for preparing equilibrium solutions and measuring the vapor pressures of motor-fuels. A series of empirical curves from which it is possible to determine, data from the distillation curve being given, the dew-point of a non-aromatic hydrocarbon fuel with a degree of accuracy sufficient for all ordinary purposes, was shown in the form of lantern slides. As a result of the work done by the authors the conclusion is drawn that the 85-per cent point is the best single measure of the effective volatility of a motor fuel from the standpoint of distribution and crankcase-oil dilution. This paper with the illustrations of the curves mentioned will be published in an early issue of THE JOURNAL.

EXPERIMENTAL SURVEY OF CARBURETION

Results Obtained at Purdue University with Kerosene and Gasoline

This paper, which was printed in the January issue of THE JOURNAL, gives in considerable detail the results of an experimental study of the carburetion of gasoline and kerosene as conducted at the Purdue University Engineering Experiment Station. In presenting this paper, C. S. Kegerreis, one of the authors, outlined very briefly the methods employed and exhibited a number of slides that showed the results of the experiments in graphic form.

In opening the discussion, P. S. Tice stated that he did not entirely agree with the points brought out by Messrs. Kegerreis and Young, since he had found that gasoline and kerosene, when used in the same engine with equal temperatures and substantially no fuel liquid on the wall, give equal mean effective pressures and thermal efficiencies with less exhaust-heat lost and proportionately the same loss to the jacket if detonation should occur. He also stated that the mixture-ratios for maximum power and maximum thermal-efficiency under equal-temperature conditions differ only as the calorific values of the fuels. It had been his experience that the maximum efficiency is not obtained at the lower limit of inflammability as stated by Mr. Kegerreis, and he believed that the conclusion arrived at by the latter must have resulted from the limitation of his method of preparing the charge, since his limits represent more fuel in the charge than the proportions found to give the maximum efficiency. Mr. Tice had found that the lower limit of inflammability is quite consistently 0.0445 lb. of kerosene per pound of dry air; a mixture ratio of 1 to 22.5. In view of this fact he was of the opinion that some of Mr. Kegerreis's conclusions on the metering requirements of the carbureter for acceleration and good car-performance under throttle manipulation were in error. In support of these points, Mr. Tice drew a number of diagrams which will be presented in a later issue of THE JOURNAL with his full discussion of the paper. In conclusion he stated that the use of a steady-flow

apparatus is of very doubtful value, particularly if the carbureter is to be used in conjunction with only four or a lesser number of cylinders.

The next speaker, H. S. McDewell, pointed out that the method employed in the paper to reproduce test conditions did not give the usual conditions that obtain in operation, since the throttle plates employed would catch the fuel that crept on the walls of the manifold and cause it to be subsequently vaporized. While the testing plant used by the authors would undoubtedly compare carbureters under the same conditions, these are not the conditions that obtain in the engine.

E. H. Sherbondy, the next speaker, said that the carbureter has two functions to perform; metering the fuel and the air and diffusing the fuel throughout the air. For that reason choke-tubes and sprays had been developed. To determine the loss of pressure across a carbureter he had built an air-meter and tested a number of carbureters of the conventional type. In making these tests he found that the pressure-drop from the entrance to the throat was greater than that through the venturi tube. By changing the form of entrance to the carbureter it was possible to pass as much air through a 1¼-in. carbureter as was ordinarily possible with a 1¾-in. carbureter of the conventional type.

J. G. Willett asked whether it would not be possible to vary the amount of air and fuel handled by the carbureter with changes in the car speed. Mr. Tice in answering this question said that the so-called fuel-lag is responsible for mixtures firing at one speed and not at another.

W. L. Dempsey expressed the view that engines should be improved, as well as carbureters. He pointed to the Diesel engine as the most economical form of power-plant, burning practically any grade of fuel without crankcase wastage. During the burning of the fuel the temperature ranges from 900 to 950 deg. fahr. In the internal-combustion engine the temperature must be kept well above the critical value at which the fuel condenses out of the mixture. At the present time the air and the fuel are mixed in the carbureter and passed on to the manifold where condensation occurs. The drawbacks of the Otto cycle are a waste of fuel into the crankcase and out through the exhaust. To secure satisfactory operation a dry gas is necessary, and if the mixture temperature is maintained above the critical point from the time the mixture leaves the carbureter to that of the end of the compression-stroke, the economy of operation will be increased. In conclusion, Mr. Dempsey emphasized the necessity of supplying sufficient oxygen to form carbon dioxide and water and maintaining a high temperature.

In response to a question by A. D. T. Libby as to whether super-heated steam was fed with the kerosene, Mr. Kegerreis replied in the negative.

Neil MacCoull said that he had noted a temperature-drop of 100 deg. with the air at 250 deg. fahr. He asked whether the spark position was kept constant or advanced in the tests. Mr. Kegerreis stated that the temperature was measured at a point 10 in. from the carbureter; also, that the spark was held at the point to give high power in all cases.

NATURAL GASOLINE AS AN ENGINE FUEL

Utilization of a Product Extracted from Natural Gas Will Relieve Shortage

The last paper presented at the fuel session was read by W. M. Welch in the absence of the author, Lloyd F. Bayer, of the Tidal Refining Co. After pointing out that the problem of securing the largest possible supply of the best possible motor-fuel is one that concerns both the petroleum and the automotive industries, the paper describes the two processes employed to secure natural gasoline, which term is accepted generally by the petroleum industry as applying to the gasoline product extracted from natural gas. The first of these is the compression process, which is applied to casing-head gas and consists in subjecting the relatively rich gas to high pressure and cooling to or below atmospheric temperature, thus resulting in the direct condensation of gasoline. In the other method, which is known as the absorption process, the gas is brought into contact with a heavy oil that originally has no gasoline content. After this oil has absorbed the gasoline it is heated to distill off the gasoline, the two operations of absorption and distillation being continuously repeated within a closed system. The use of natural gasoline to render certain fractions of the crude oil that of themselves would not meet the requirements of an acceptable grade of motor-fuel sufficiently volatile for satisfactory use is gone into at some length. To assure the greater volatility necessary in winter with motor-fuels, particularly those of high end-point, it is desirable to increase the percentage of natural gasoline used. This is practicable since the consumption of gasoline is much less in the winter than in the summer, while the production of natural gasoline increases to some extent in the winter. Mr. Bayer stated that the production of natural gasoline amounts to about 10 per cent of the total gasoline production, and that this is a very satisfactory proportion in which to use natural gasoline with the average motor-fuel to give it the desirable volatility characteristics.

In the past the use of natural gasoline has been attended with varying success, depending altogether upon the intelligence that was displayed in combining it with other products to form the finished motor-fuel. This formerly resulted in the use of a blended fuel that was unsatisfactory for a number of reasons, but the Association of Natural Gasoline Manufacturers is making every effort to produce only blends that will be satisfactory. Dynamometer tests have shown that the addition of 15 per cent of natural gasoline to a good commercial gasoline increases the brake horsepower developed and decreases the fuel-consumption per horsepower-hour. The starting and accelerating characteristics were improved as the percentage of natural gasoline was increased, this improvement being very marked at 10 per cent and reaching a maximum when 15 per cent of natural gasoline was added. Another advantage of the use of natural gasoline is that the initial boiling-point can be lower and the percentage distilled off at 212 deg. fahr. materially increased.

ARE WE INTERESTED IN HIGH COMPRESSION?

Its Effects on the Internal-Combustion Engine Analyzed and Discussed

In opening the session devoted to a discussion of the subject of detonation, Chairman H. L. Horning called attention to the three fundamentals, reaction-velocity, compression and temperature, as the factors influencing detonation. He spoke of how specifically the three papers presented dealt with these factors and asked that they be kept continuously in mind whenever detonation was under consideration.

The paper by J. H. Holloway, H. A. Huebotter and G. A. Young is a report of a series of tests they con-

ducted during the summer of 1922 at the Purdue University Engineering Experiment Station and was published in the January, 1923, issue of THE JOURNAL. The work consisted of research into the operation of internal-combustion engines under comparatively high compression on ordinary gasoline without detonation. The compression-ratio of the engine was 6.75 and the compression pressure was 122 lb. per sq. in., gage. The ingoing charge was passed through a hot-spot vaporizer and thence through a cooler between the carbureter and the valves. Jacket-water temperatures between 150 and 170 deg. fahr. were carried at the outlet port of the jacket.

The source of the two phases of detonation encountered in this work is believed to be overheated areas in the combustion-chamber. The methods of combating these hot spots were stated in detail, and the special equipment applied to the engine to accomplish the desired result was described. The effects of load, speed, compression-ratio and mixture-ratio were studied, and curves showing the variation in the engine characteristics due to each factor were submitted. All these tests were run without a trace of detonation, and the results of the work indicated the following conclusions:

(1) Automobile engines designed to give a uniform cooling of the combustion-chamber walls will permit the use of much higher compression-ratios than those employed at present, with a consequent gain in engine power and economy

(2) The fuel-air ratio for maximum economy borders upon the lean limit for reliable combustion

(3) For maximum power, the mixture-ratio used need not exceed 0.075 lb. of gasoline per lb. of dry air

(4) With concentrated heating of the mixture at the carbureter outlet, a local temperature of 125 deg. fahr. is sufficient to give good operation at full throttle

(5) Cooling to 100 deg. fahr. at the valves is desirable if the compression pressure of the engine is high

(6) At part loads, a hot-spot temperature of 175 deg. fahr., with or without intermediate cooling, will give good results with lean mixtures

WHAT CONDITIONS CAUSE DETONATION?

An Explanation of the Natural Factors That Govern This Gaseous Phenomenon

The second paper presented at the detonation session, by Thomas Midgley, Jr., and Robert Janeway, analyzed the laws that govern gaseous detonation. The authors gave an explanation of detonation based upon what are considered incontrovertible facts, showing by the functioning of well understood natural laws that gaseous detonation is a phenomenon that does not require any hypothetical assumptions to account for its existence.

The physical conditions that must exist within an enclosed container when it is filled with an explosive mixture of gases and these gases are ignited were stated and analyzed mathematically, and an application of this analysis was made to the internal-combustion engine. The apparatus and the procedure were described, inclusive of illustrative views and charts, and it was shown how the formulas can be applied, (*a*) for constant throttle and varying the temperature of the entering charge and (*b*) for constant temperature and varying the throttle opening and the compression-ratio. The results were discussed in some detail. In addition, reference was made to two of the basic equations and they were combined into a single fundamental expression containing only two variables. Further, a mathematical determination was made of the critical pressure of detonation.

SPECIAL ASPECTS OF THE FUEL PROBLEM

Suitable Fuels for Use in High-Compression Engines for Aeronautic Usage

The final paper at the detonation session dealt with testing fuels for high-compression engines. It was written by Stephen M. Lee and Stanwood W. Sparrow, and was read by Mr. Lee; it had been printed in the January, 1923, issue of THE JOURNAL.

The paper treats certain of the methods used and the results obtained in two investigations, the fuels in question being benzol and ethyl alcohol, either alone or as blended with gasoline.

The authors emphasized the necessity of mixture-ratio runs when making fuel investigations. Since the tendencies of a fuel to detonate or preignite limit the conditions under which it can be used, the methods of estimating these characteristics were discussed. A graphical representation was made to illustrate the relation between compression pressure, compression-ratio, volumetric efficiency and indicated power so that, with a given engine, the effect on detonation of changing engine conditions could be estimated.

Results characterizing the performance of the different fuels were mentioned, and particular attention was directed to cases where these results are in contrast with current opinion.

THE BIG NOISE OF CYLINDER DETONATION

Its Causes Analyzed in the Light of Present Knowledge and Research

The discussion at the detonation session verified the prediction made by Chairman Horning that the subject matter would inspire the many prominent members of the automotive and allied industries who were present. The rapid-fire questions and answers that were exchanged between the members of the audience and the authors of the papers gave proof of such inspiration.

Thomas Midgley, Jr., when opening the general discussion, asserted that the physical characteristics of the fuel used must be known and specified for all investigations concerning detonation.

E. D. Thurston, Jr., called for discussion with regard to best power and economy and how they are related to the best fuel.

Dr. H. C. Dickinson read written comment from J. G. Vincent, who was unable to be present, regarding the subject of "rough" engine operation, which was tied to statements regarding this matter made in the Holloway, Huebotter and Young paper, by Chairman Horning.

S. W. Sparrow spoke of the need of recognizing the importance of compression pressure over that of compression-ratio.

S. D. Heron discussed internal engine-temperatures with reference to the shape of the combustion-chamber, and P. S. Tice referred to combustion-chamber shape and the effect of mixture temperature on the high-compression method. Mr. Tice mentioned also that detonation occurs in a definite relation to the initial temperature of the charge; the lower the initial temperature is, the less the tendency to detonate will be.

A lengthy exchange of opinions was had between

numerous discussors regarding whether the high value or the low value was used, or should be used, as the heating value of a fuel under consideration. While no conclusion was reached, the wide variations in practice were made evident.

Many interesting questions and answers referred to the Midgley and Janeway paper, but their details are too intricate for a general report and must be reserved for publication later. It was brought out that the detonation values given by Mr. Midgley apply only to the particular engine that was used, and that these values would be different for each engine under consideration.

In connection with the Lee and Sparrow paper, with regard to the liability of burning the valves when using benzol as a fuel, it was stated that this effect had been found to be no worse than when using aviation gasoline. With reference to remarks made comparing constant-volume with constant-pressure engines, Mr. Lee stated that the efficiency is mainly dependent upon that of the air-cycle. Mention of the possibilities of the Diesel engine elicited numerous comments comparing Diesel-engine fuel-consumption with present-day automotive-engine results in this regard, expansion-ratios were discussed with reference to smooth running and the relative merits of thin and thick cylinders were accorded attention.

The foregoing sketch of the proceedings at the detonation session are only indicative; their complete presentation in an early issue of THE JOURNAL will be necessary before their full import can be comprehended.

RESEARCH PROMISES FUEL SAVING

Results of Society's Cooperation with Petroleum Industry Discussed

In the absence of Past-President J. G. Vincent, who was unable to be present, President B. B. Bachman presided at the Research Session of the Annual Meeting, which was held on the morning of Thursday, Jan. 11.

HOW THE RESEARCH WAS ORGANIZED

H. M. Crane, chairman of the Research Committee, confined his attention to the fuel activities of the Committee, in presenting the 1922 Report. Tracing the history of the Society's work on fuel for the past 3 years, Mr. Crane brought out the importance of the gradual rapprochement that has taken place between the petroleum producer and the automotive engineer, culminating in the undertaking of a joint research on the fuel problem 1 year ago. This concerted action had served, not only to clarify the issues involved, but also to insure the formation of rational conclusions.

The fuel research fell into two parts, one a program carried out last summer by the Bureau of Standards, a report of which appears elsewhere in this issue, and the other a program carried out by 10 companies in the Detroit district, working under the direction of the Research Department. Both tests covered a wide range of cars, typical of about 75 per cent of the total number in use in the Country, under a very considerable range of operating conditions. Mr. Crane explained that the problem under consideration had two phases, the question of the type of fuel that the operator would like to use if he could get it, and the question of what is the greatest departure from the theoretically best fuel that can be handled successfully in the present-day automobile.

The chief difference between the Bureau of Standards tests and those conducted by the companies was that the latter represented a somewhat more advanced product than was represented in the Bureau tests. In other words, many of the cars used in the companies' tests were of uptodate design.

THE RESULTS SUMMARIZED

The results of the tests indicated that in warm weather, purely from a mileage point of view, a fuel considerably worse than what is now being supplied would produce mileage almost in proportion to the quantity consumed. The company tests seemed to indicate less satisfactory results with the heavier than with the lighter fuels.

Mr. Crane reported the results of a test run made by another member of the Society, which showed that greater maximum-acceleration and car-mileage could be obtained with a fuel much lighter than commercial gasoline, by regulating the jacket-water temperature. The conclusion was that high volumetric-efficiency is incompatible with the best use of heavy fuels; that better results are obtainable with lighter than with heavier fuels in cars adapted to lighter fuels, but that in cars adapted to heavier fuels the use of the lighter ones gives no advantage. Crankcase-oil dilution is a sensitive index, but Mr. Crane declined to accept the presence of this phenomenon as evidence of the inadmissibility of any fuel.

R. E. Carlson's paper, which appears elsewhere in this issue, summarized the results and conclusions derived from the tests last summer of the four experimental fuels in four different models of car, which showed no significant difference in fuel mileage for the different fuels. He described also the results to date of experiments on a single engine mounted in a refrigerator chamber, the tests covering a wide range of operating temperatures. It is too early to draw definite conclusions from these tests. The series of cold tests will be supplemented by such road tests as appear necessary from the results obtained.

W. S. James continued the discussion of the project by explaining that the results so far obtained in the cold-chamber test cover a condition at the low-temperature end in which the fuel in the manifold must be mostly liquid, and at the high-temperature limit a condition of almost complete vaporization.

All of the four fuels may act alike when supplied to the engine as liquids, or as vapor, but differently when partially vaporized. The tests made so far may not cover the condition of partial vaporization, when maximum differences between the four fuels would become apparent. Mr. James illustrated this point by a sketch showing how the distribution of either a liquid or a vapor to the different cylinders may be uniform, while the distribution of a mixture of a liquid and a vapor may not be uniform. The Bureau will make further tests to clear up this point.

TEN COMPANIES COOPERATE IN SERVICE TESTS

V. H. Gottschalk presented a report of the service fuel-tests run last summer by 10 companies in cooperation with the Research Department of the Society, using four fuels very similar to those used at the Bureau of Standards. In this series, 59 different passenger-cars of about 15 different models were run in ordinary service, each car running 1 week on each of the four fuels.

The results of these tests showed remarkable consistency in the mileages secured with the four fuels in all of the different models, the differences being not over 1.9 per cent on the average. Measurements of crankcase-oil dilution, however, showed a consistent increase from

the *A* fuel to the *D* fuel; with some of the cars the dilution with the *D* fuel was twice that with *B* or commercial-grade gasoline.

Petroleum Industry Well Represented

Dr. Van H. Manning spoke on behalf of the petroleum industry. He emphasized the fact that cooperation between the two industries has resulted in the education of both. The oil industry will keep pace with the automotive industry in its development work.

T. J. Litle said that the important point in these tests is that the drivers do not like the *D* gasoline. We may be able to use it if necessary, but we would much prefer to use something better. In this connection he wished to know why the petroleum industry did not make more use of cracking processes.

F. A. Howard, replying to Mr. Litle, said that cracking in effect increases the supply of available crude but does not increase the percentage of good fuel. C. S. Kegerreis emphasized the difficulties in starting and in crankcase dilution experienced with the use of fuel *D* and considered that it would take time to adapt automotive equipment to its effective use.

In connection with the difficulty experienced in starting, O. C. Rohde stressed the importance of spark-gap setting. H. E. Pengilly suggested that the relatively better performance of the *B* or commercial-grade fuel was due to the fact that the manifolds, on the average, were heated to the temperature that suits this grade. He expressed the opinion that if the results were examined carefully it might appear that some of the cars were better adapted to make use of the heavier grades of fuel efficiently.

Herbert Chase asked if further data could be given on the types of car used in the tests by the 10 companies. Dr. Dickinson explained that more data were not given because some of the companies did not want their cars identified. He stated that a similar series of tests will be run by some or all of the same companies during winter weather.

AIR-COOLED PASSENGER CARS ADVOCATED

How Designers of Automobile Engines Can Benefit from Aircraft Practice

T. J. Litle, Jr., presided at the engine-cooling session held Jan. 12 as the closing feature of Annual Meeting week. He believes, as stated in his opening remarks, that the air-cooled passenger-car engine will be supreme, but that we do not know how to build it as yet. He expressed high appreciation of Mr. Heron's paper as another valuable contribution from the Government to automotive development, and said that automotive engineers often fail to realize how greatly the progress of the industry is assisted by such governmental agencies as the Air Service and the Bureau of Standards, in view of the research data that the Government makes available from time to time in the published reports of these organizations.

The paper by S. D. Heron on Aircraft-Engine Practice as Applied to Air-Cooled Passenger-Car Engines, which was printed in the January, 1923, issue of THE JOURNAL, was presented by the author briefly, in abstract form, with running comment on the actual text. He stated that most of the copying of aircraft practice in postwar car-design had proved a failure because the fundamental difference in duty had not been realized, and proposed to show wherein the automobile designer and the engine builder can profit by the use of the practice developed for air-cooled aircraft-engines. After generalizing on the main considerations involved, he gave an exposition of the simplicity of layout of the efficient air-cooled cylinder, as a preface to a somewhat detailed discussion regarding cylinder design and performance, inclusive of valve location, types of finning and the form of the cylinder-head.

Cylinder material, cooling surface, port-arrangement for in-line engines and the camshaft and valve-gear arrangement most desirable were treated at length and illustrated. A consideration of sleeve-valve types, temperature and exhaust-valve cooling followed, accompanied by many enlightening data. Similar treatment was accorded the subjects of air supply, a cooling system for in-line engines, air-blast direction and the necessary quantity of air.

The desirable types of fan, spark-plug, piston and fuel were commented upon somewhat briefly. Mr. Heron concluded that (*a*) the scaling-down of design in internal-combustion-engine cylinders is a safe process, while scaling-up is decidedly unsound; and that (*b*), since thermal troubles have been the greatest cause of difficulty with air-cooled cars, a consideration of the designs capable of full-throttle operation is likely to demonstrate the ease with which the relatively mild thermal efficiencies of an air-cooled car can be overcome.

The two appendices to this paper, by C. Fayette Taylor and E. H. Dix, Jr., respectively, related to the experimental development of air-cooled engine-cylinders and the foundry production of air-cooled cylinders having the fins cast integrally.

RADIATOR CAPACITIES FOR COOLING

Heat-Dissipating Properties of Three Types of Radiator Core

The last paper of the session devoted to engine cooling was presented by Prof. E. H. Lockwood and gave the results of an investigation made at the Mason Laboratory, Yale University. Its title is the Cooling Capacity of Automobile Radiators. It was published in the January, 1923, issue of THE JOURNAL.

The three types of core investigated include the fin-and-tube, the ribbon and the air-tube groups, classified thus according to the flow of the water and the air. The ratios of the cooling surface to the volume are shown to be nearly the same in the fin-and-tube and the air-tube cores; in the ribbon core the ratio is somewhat greater.

Professor Lockwood derived a formula for computing the heat-transfer coefficient, which is defined as the number of heat units per hour that will pass from one square foot of surface per degree of temperature-difference between the air and the water. This coefficient is the key to ascertaining radiator performance; by the use of it, almost any desired information can be obtained.

When the heat-transfer coefficients have been found for a sufficiently wide range of water-flows and air-flows, the cooling capacity of a radiator can be computed for any desired condition. Five fundamental formulas were given, together with six derived formulas, the mathematics involved being given in an appendix.

The formulas cover topics such as pump circulation, thermo-syphon circulation, the limiting depth of core required, final temperatures, weight of water-flow and the like. The results of applying the formulas to six cores that were selected as representative of the three main types of radiator construction were illustrated by a series of charts.

ENGINE COOLING FROM VARIOUS ANGLES

An Indication of the Trend of Thought Regarding Cooling Systems

Various phases of the subject were discussed after the presentation of the papers at the session devoted to engine cooling. The subject of cooling by the auxiliary use of steam was treated. Some further information regarding the practical use of the Lockwood formulas for radiator calculations was presented.

S. D. Heron demonstrated a working model of a pattern for use in casting an air-cooled cylinder, explained the foundry process and exhibited other patterns for some of the cylinders illustrated in his paper.

L. H. Pomeroy doubted the success of the air-cooled engine for high-class passenger-car service, because of factors that tend to make it noisy. He believed that the chief source of noise lies in the variations of temperature and also that the control of vibration is influenced by the temperature differences. Further, that if high internal friction is a characteristic of an air-cooled engine, it is not a satisfactory powerplant.

C. P. Grimes presented interesting comment on the performance of the well-known air-cooled car he represents, together with remarks on cylinder cooling-fins, fans and the starting of cold engines.

H. S. McDewell expressed the opinion that the air-cooled engine would now have the advantage, if the same amount and quality of research work and development had been applied to it as have been expended upon the water-cooled engine. He believes that engine designers are not in close enough touch with aircraft-engine practice. He called attention to the fact that air and water-cooled engines are both cooled also *by oil*, and that this factor should not be neglected. His view concerning the scaling-down of engines as being safe, and the scaling-up being decidedly unsound, coincides with that expressed by Mr. Heron.

Thomas Midgley, Jr., gave an outline of the benefit obtained by using copper as a surface for cooling.

C. Lawrance made remarks concerning internal engine-friction and stated that it is always desirable to remove heat first from the point nearest its source. He believed that successful air-cooled engines can be produced in sizes that are suitable for automotive usage.

Dr. H. C. Dickinson mentioned the desirability of maintaining uniformity of the cylinder temperature, Chairman Litle spoke of having seen red-hot valves on a water-cooled engine and Mr. Grimes stated that the temperature of an engine cylinder is not related to the economy of an engine.

Mr. Heron, in conclusion, commented briefly upon the various questions. He mentioned factors that tend to produce silent engine-running, and discussed temperature control of the air-cooled engine. He thought that fins cast integrally with the cylinder are most successful.

MOTORBOAT ENGINEERS MEET

J. G. Vincent to Present Paper at Motorboat Meeting on Feb. 28

The annual Motorboat Meeting of the Society will be held at the Hotel Commodore, New York City, Feb. 28, at 10 o'clock. The date selected occurs during the week of the National Motorboat Show in New York City. A group of papers on motorboat subjects will be read and discussed in the meeting, and an informal lunch will follow at 1 o'clock.

J. G. Vincent, vice-president of the Packard Motor Car Co., will read a paper on Modern Tendencies in High-Speed Motorboat Engine Design. Mr. Vincent's success in winning the Gold Cup Trophy with his "Packard Chriscraft" and his standing as a designer of aircraft and automobile engines, assure the members of an interesting and informative paper. Efforts are being made to secure a paper on Diesel engines for yachts and a brief talk by a motorboat owner on the improvements in motorboat engines that the owner considers desirable from his standpoint.

Final details of the program for this meeting will reach the members in the *Meetings Bulletin* about Feb. 15.

ANNUAL MEETING IN DETROIT

Decision Made to Locate It in the Middle West in 1924

The next Annual Meeting of the Society will be held in Detroit in January, 1924, probably during the week preceding the Chicago Show. This recommendation of the 1923 Meetings Committee was approved at the first session of the new Council of the Society last month. Such a distinct departure from past precedent has not been made without careful study and sufficient reason. The demand for a change in the time and the location of the Annual Meeting has grown with each succeeding year, and now it is believed good judgment to alter precedent for the best interests of the Society.

It has been the belief in the past that holding the Annual Meeting coincident with the national automobile show in New York City resulted in a larger and more representative attendance. Some have argued that without the dual attraction the meeting could not be successful. This argument is disproved by the success of the Production Meeting in Detroit where, with the meeting as the sole attraction, technical sessions were attended by the largest audiences ever attending Society meetings, and nearly 500 were seated at the dinner. When programs are attractive, subjects timely, speakers are authorities and distances not too great, members will be drawn to Society meetings in satisfactory numbers.

Show Week Unsatisfactory Time

Probably the strongest argument against the New York City meeting has been its conflict with other matters of greater urgency to members attending the show. Every visitor to New York City feels in duty bound to make a careful study of the exhibits at the show. This is impractical in the evenings because of the crowds, and must be done during the day in conflict with Society meetings. Organization, dealer and sales luncheons and business meetings are other conflicting events. Many members find it altogether impossible to leave the headquarters of their companies for any appreciable time during the show period. Evenings are crammed with business and social activities that make one reluctant about arising early and attending professional sessions. It seems nearly impossible to get meetings started on time during show week; in Detroit, where the meeting was the sole attraction, sessions started promptly with a satisfactory audience in point of numbers.

The New York Show always attracts the major executives from the factories with the natural result that many engineers and production men in minor capacities must remain at home. A meeting arranged at any other

period would probably find these younger men able to leave their work. With a location more nearly in the center of production, travel expense of the younger men will be decreased, and they are more apt to attend the meetings. The Annual Meeting is considered generally as the most representative meeting held by the Society during the year; the attendance of the younger men who are destined to carry on the future work of the Society, is highly desirable for this reason.

Summer Meeting Location a Factor

The Meetings Committee has met an extremely difficult problem in the selection of a suitable place for the Summer Meeting of the Society. It seems to be the general opinion that most of the popular resorts suited to our peculiar requirements lie in the Eastern region. It has always been the custom to hold the Summer Meeting in the Middle West and the Winter Meeting in the East. A change in this practice will overcome the Show Week handicaps just enumerated, and place the Summer Meeting in a district that includes many splendid resorts with adequate hotel and recreational facilities. This move seemed logical, and was an important factor in locating the Winter Meeting in the Middle West.

Annual Dinner Remains in New York

The Annual Dinner of the Society will continue to be held in New York City on Thursday evening of Show Week. This dinner has become recognized as an institution; it continues to attract the industry's most representative men, and there has been no suggestion of discontinuing it or changing its time or location. The annual sessions of the Standards Committee will also continue to be held in New York City at show time. This practice makes it possible to either shorten the Annual Meeting period or devote another day to technical matters in Detroit. It also allows a longer period before the Summer Meeting for the formulation of new standards and recommended practices.

NATIONAL TRACTOR MEETING

Chairman Rumney of the Meetings Committee has appointed H. O. K. Meister chairman of a special committee that will arrange a National Tractor Meeting of the Society sometime during the spring. The location and date of the meeting will be selected to coincide with some national tractor activity, such as a demonstration or show, enabling a large number of tractor men to attend. Any suggestions or offers of cooperation in the arrangement of the Tractor Meeting should be addressed to the New York office.

AUTOMOTIVE TRANSPORT MEETING

Truck, Bus, Taxicab and Rail-Car to Be Treated at Cleveland Meeting

A National meeting of the Society devoted to commercial automotive transportation will be held at Cleveland some time in April. Although the date of the meeting has not been set, the plan of the technical activities has been defined. There will be at least four engineering sessions devoted respectively to truck, motorbus, taxicab and motor rail-car transportation. Operation rather than design will be featured in the truck and motorbus meetings. The taxicab session will include papers on both design and operation. Representative motive power engineers of railroads that have experimented with rail-cars, are being asked to contribute their experience to the rail-car meeting.

The preliminary arrangements for the Cleveland Transportation Meeting are in charge of a sub-committee of the Meetings Committee headed by A. J. Scaife. Requests for representation on the program should be addressed to the Society headquarters in New York City. Progress in the arrangements will be recorded in future issues of THE JOURNAL and the *Meetings Bulletin*.

1923 PRODUCTION MEETING

Factory Problems Subject of National Meeting in Cleveland Next October

The Meetings Committee announces that the 1923 Production Meeting will be held at Cleveland during October of this year. This is in accordance with the plan in mind when the Detroit Production Meeting was arranged, that is, the meeting site will be changed from year to year, but will be located in the region where the major portion of automotive parts and vehicles are produced.

Papers for the 1923 Production Meeting are being solicited at the present time. Perhaps you have a subject in mind for discussion at this meeting; or, better still, you may wish to present a paper. Write to the New York office of the Society and submit your suggestions. Papers on new processes, shop methods or production research are welcomed. We require timely papers on factory economics, wage systems, planning, purchasing and allied subjects. Selection of papers will be on a competitive basis, the papers of greatest practical value being given places on the program. The committee hopes even to surpass the unusually successful Detroit meeting, and asks the earnest cooperation of every man engaged in the producing branch of the industry.

INDUCTOR MAGNETO ADVANTAGES

Engineer Outlines Them at Section Meeting in Boston

M. E. Toepel, electrical engineer with the International Motor Co., addressed the members of the New England Section at their meeting on Jan. 18 in Boston. He described recent developments in the polar-inductor type of magneto, stating that this type had greater possibilities than either the rotating armature or the shuttle type. Important magneto parts can be replaced more easily in the polar-inductor magneto, spark characteristics can be changed to suit any individual requirement and it is possible to have all sparks of the same polarity. There are two important disadvantages met with in polar-inductor magnetos; losses in magnetic flux transmission to the core of the winding and loss of efficiency when the relation between the magnetic and the mechanical break is altered by the wear of the actuating parts. Mr. Toepel made a plea for better weatherproofing of magnetos, referring particularly to accomplishing this within the magneto rather than by providing special covers, gaskets and the like.

A high-speed engine with positively operated valves will be described by Rollin Abell at the meeting of the New England Section to be held, Feb. 15. A single poppet valve is used in each cylinder of this engine, this being put in communication alternately with inlet and exhaust-ports by a rotary distributor valve placed lengthwise of the cylinder-head. It is claimed that the trapping of a small charge of exhaust gas at the end of each

exhaust stroke and the dilution of the incoming charge with this exhaust gas, makes it possible to use high compression without any resultant detonation. The meeting will be held at the Buckminster Hotel, starting at 8 o'clock, and all members and their friends are invited to hear Mr. Abell's interesting paper.

KETTERING FAVORS RESEARCH

Surest Means of Avoiding Crystallization and the Saturation Point

C. F. Kettering was in particularly good form when he addressed the Buffalo Section members at their annual dinner, Jan. 18. He based his talk on a heading he had noticed in an advertisement in one of the weekly magazines, "Search for Spices Led Columbus to Discover America." The determination to accomplish a specific purpose led Columbus to make a far greater and more important discovery. Mr. Kettering stated that a similar result was often encountered in physical research. It was with the purpose of finding a satisfactory method of burning kerosene in internal-combustion engines that the members of Mr. Kettering's research staff were led through a long series of experiments to the fundamental causes of detonation and the discovery of anti-knocking dopes. Mr. Kettering recommended that all research be started with a definite purpose in mind, but we must not be surprised if our course leads to discoveries that were not anticipated.

The research man must be continually asking, "Why?" He must not accept everything as being fundamentally correct in its present state. His viewpoint must be a constantly changing one. He must not settle down to the state where he feels that everything is satisfactory; he must ask himself, "Why do I do this thing this way?" The fact that a thing has never been done must not discourage him in attacking a problem. He must set upon the problem as it exists and determine why it has never been solved.

As an illustration of the viewpoint a research man must take, Mr. Kettering quoted a recent experience he had had with automobile painting. He asked his men this question: "Why not paint an automobile body in 1 hr. instead of 30 days?" The question appears ridiculous until it is realized that the research man immediately perceives that he must attack the painting problem in an entirely new way if he is to make a satisfactory investigation. He immediately realizes that such a saving of time cannot be accomplished with the present methods and materials. This particular investigation did not lead to the discovery of a method of painting automobiles in 1 hr., but it did lead to a surprisingly productive piece of research, as a result of which the time taken to paint an automobile at present will be materially reduced.

It is Mr. Kettering's belief that research and continuous development will be the salvation of the automotive industry. The oft-anticipated point of saturation will not be reached so long as each new crop of automobiles represents a material engineering advance over those of the previous year. We must not let the automotive industry crystallize; we must not accept our present automobiles as satisfactory. It is Mr. Kettering's belief that there is plenty of opportunity for the further development of the present-day automobile. He cited tire-changing and ill-fitting side curtains as two examples of items that are far from the ideal. We must continue to build automobiles of the finest material and with the best workmanship, but improvement must be rapid, so that the new models shall be attractive enough to the owner to make him anxious to part with his old car. Automobile design must and will change in the next five years because of public demand and a continuing incorporation of the results of scientific investigation into the finished product.

Charles L. Sheppy acted as toastmaster of the dinner. The speaking program was followed by a most enjoyable program of entertainment, all the talent being members of the Buffalo Section. Otto M. Burkhardt and the members of his Dinner Committee are to be congratulated on the success of the dinner and the enthusiasm it will undoubtedly arouse among the Buffalo members of the Society.

RADIO BROADCAST SUCCESSFUL

A group of letters received from enthusiastic radio listeners throughout the country is evidence of the success of the radio broadcasting of the Annual Dinner of the Society in New York City. Letters have been received from points as far distant as La Crosse, Wis., Quebec, Canada, Anderson, Ind., Augusta, Me., and Ashland, Ohio. Members of Mr. Kettering's family at his home in Ohio heard his remarks as toastmaster.

The success of this innovation will result undoubtedly in the broadcasting of future programs of the Society. Papers at the technical sessions are not suitable for broadcasting because of their usual complexity and lack

Schedule of Sections Meetings

FEBRUARY

2—DETROIT SECTION—Production Meeting—The Organization of Motor-Car Construction from Layout to the Finished Car—L. V. Cram, H. W. Hayes and others

2—WASHINGTON SECTION—Research in Aeronautics—George W. Lewis; Recent Developments in Aircraft Power-plants in the Navy—Lieut. B. G. Leighton, U. S. N.

7—MINNEAPOLIS SECTION—Transportation on the Upper Mississippi River via Barge, Motor Tow-Boat and Terminal Delivery by Truck—J. S. Brodie

8—INDIANA SECTION—Practical Application of Lubricants—W. F. Parish

8—METROPOLITAN SECTION—Joint meeting with Automotive Service Association—Relation of the Service Station to the Factory and Engineering Dept.—Speakers, J. W. Lord and B. B. Bachman

15—NEW ENGLAND SECTION—A High-Speed Engine with Unconventional Valve-Gear—Rollin Abell

20—DAYTON SECTION—Alloy-Steel Valves and the Effect of Heat on Various Steel-Alloys—Robert Jardine

21—PENNSYLVANIA SECTION—Lubrication Meeting

23—BUFFALO SECTION—The Manufacture of Wire Wheels—W. W. Davison; The Future of the Steel Disc Wheel—J. W. White

of appeal to the general class of radio listeners. The radio broadcasting stations have shown an interest in popular talks, however, and those Society programs that appeal to the public will probably be carried via air to our members in the future.

FEATURE PRODUCTION MEETINGS

Detroit Section to Devote Series of Meetings to Factory Problems

The Detroit Section intends to devote all of its meetings during the remainder of the Section year to matters closely related to the producing arm of the industry. It is the intention to discuss jointly the engineering and the shop phase of each problem with the commendable object of bringing designing and producing men into closer relationship. Interest in the meetings is being stimulated among factory men and a large attendance seems assured.

The first meeting of the series is scheduled for the evening of Feb. 2 at the General Motors Building on the Grand Boulevard. The Section will hold all of its meetings at this new location in the future. L. V. Cram of the Chevrolet Motor Co., H. W. Hayes of Dodge Bros. and representatives of the Ford and Studebaker production divisions will address the meeting. They will speak on consecutive steps in the Organization of Motor-Car Construction from the Layout to the Finished Car. The meeting starts at 8 o'clock and will be preceded by an informal supper at 6:30 p. m.

MID-WEST SECTION LUNCHEON

The Mid-West Section held an informal luncheon in Chicago, Jan. 16, for the purpose of selecting a nominating committee whose duty it will be to select a ticket of officers for the next Section year. The committee consists of B. S. Pfeiffer, W. O. Olson, F. H. Ford, W. L. Kaiser and H. E. Kirby. Reports were made by several committees, that on membership showing that the Mid-West Section has 132 members in good standing. Plans for Mid-West Section activity at the summer meeting were discussed.

GUERNSEY TALKS ON RAIL-CARS

Tells Cleveland Section That Demand for Them is Limited

Charles O. Guernsey addressed the Cleveland Section of the Society on Jan. 19 with particular reference to the self-contained railroad car. Mr. Guernsey confirmed the remarks of Elisha Lee, vice-president of the Pennsylvania Railroad Co., whose address at the Annual Dinner of the Society is printed in this issue of THE JOURNAL. He stated that the railroads require a vehicle that will carry approximately 80 passengers at a speed up to 40 m.p.h. and is capable also of carrying a proportionate amount of baggage.

Mr. Guernsey touched on the possible market for such a vehicle and it was somewhat surprising to learn that some estimates placed this as low as 1500, the highest estimate being about 7000 units. In the course of the discussion, which was very animated, several speakers took exception to this figure and thought that possibly this was the usual under-estimate of a new proposition. It was brought out in the discussion, that the expected life of a motor rail-car was about 12 years. This would require a probable production of between 300 and 400 per year. Mr. Guernsey pointed out that the situation was further complicated by every railroad insisting upon its own specifications with the result that practically every vehicle was a problem in itself. The automotive engineers' work on the rail-car is bringing the advantages of alloy-steels and anti-friction bearings forcibly to the attention of the railroad people.

MOTORBUS CHASSIS MUST BE SPECIAL

Service Conditions Demand a Vehicle Suitably Designed to Meet Them

The time is past when any good motor-truck chassis equipped with a bus body is a satisfactory public conveyance, in the opinion of H. L. Bollum, president of the Twin City Motor Bus Co. of Minneapolis. Mr. Bollum addressed the Minneapolis Section of the Society on the evening of Jan. 3. The trend of motorbus design is toward longer wheelbases, wider frames and a lower center of gravity. It is not reasonable to suppose that any chassis can be built so that it will meet the requirements of all operating conditions. Different motorbus chassis will be needed just the same as truck operators require trucks of differing capacity. Mr. Bollum felt that there will be as much difference between the different types required as there is between a touring car and a heavy truck.

It is generally agreed that the fundamentals of good motorbus design are stability and easy riding; touring-car ability with motor-truck stamina is wanted. Strength is essential not only for durability but also for safety. Ease of handling is another important factor since the average driver is capable of only a given amount of work and the easier his bus steers and handles, the more mileage he can cover in a day's work. Ease of operation also lessens accident hazards.

Mr. Bollum is an advocate of the unit repair system where any unit such as an engine or rear axle can be taken out and replaced from stock with another unit. Under this system, the worn part can be repaired without unnecessary delay to the whole motorbus.

The driver is the largest contributing factor to successful motorbus operation, in Mr. Bollum's opinion. Upon his ability, enthusiasm and loyalty to his employer depends the difference between excessive and nominal operating costs. His actions have a direct bearing on every item of expense. He must be a chauffeur, mechanician, conductor and ticket agent all in one. He is the medium of contact between the public and the company. Upon him rests the responsibility of maintaining his schedule, collecting all the fares and acting as a general information bureau. His employer expects him to look neat and clean despite the fact that he must change tires and make roadside repairs and adjustments occasionally. He must know his place and not be presumptuous, at the same time tactfully informing passengers that he cannot carry on a conversation and drive a motorbus at the same time.

M. O. Moeller presented a well prepared paper on the Mechanical Requirements of Bus Service. He took up each unit in the motorbus chassis and explained the special design considerations that must be kept in mind when building a satisfactory motorbus chassis.

The next meeting of the Minneapolis Section will be held on Feb. 7 and will be addressed by J. F. Brodie. Transportation on the upper Mississippi will be outlined

giving the present possibilities for river transportation in coordination with motor transport. Mr. Brodie will discuss operations by motor tow-boat comparing gas and heavy oil engines and screw propulsion as opposed to paddle wheels. Terminal facilities will be touched upon as well as the delivery and collection of freight by motor truck. Minneapolis Section meetings are held at the Builders Exchange and start at 8 o'clock.

TRUCKS CANNOT SUPPLANT RAILROADS

Motor Transport Officer Presents Army's Emergency Control Plan at Washington

Motor transportation can never, either in an emergency or in daily commercial practice, replace the long-haul railroad service in this Country. This is the belief of Major Brainerd Taylor of the Quartermaster Department of the United States Army who addressed the Washington Section of the Society on the evening of Jan. 5. Major Taylor was detailed to represent the Army highway transport engineers in preparing a plan for relieving the emergency during the railroad strike of 1922. He presented the details of this plan at the Washington Section meeting showing a map and a manual prepared by the Motor Transport Corps for use by civilian and Army truck organizations.

Major Taylor said that the intense school of highway transportation in France during the war was the best school in which a highway transport engineer could possibly have received his education. The field of practical highway transportation in the American Expeditionary Force was more valuable to commerce than any field of transportation that commerce itself has developed so far. The highway transport engineer is still a new and much doubted individual. If there were more of them we would not hear so much about "Ship by Truck" but would hear more about "Ship by Highway Transport." The automobile industry would not be selling trucks, it would sell fleets of trucks. The railroads would not be talking about taxing the truck operator for the use of highways to make competition fair, for they would be the greatest beneficiary from a highway transport service that radiated from their terminals.

In the emergency plan described by Major Taylor, coordination of motor transportation with rail and water transportation and highway traffic control are exercised from the offices of motor transport centers by chief dispatchers, through truck dispatchers who are located at garages and cargo-spotters who are located at railroad and waterway stops and terminals. The truck equipment at each of the motor transport centers bears a direct relation to the amount of city and country freight collected and distributed from railroads and waterway terminals in that district.

The maintenance of motor vehicles in the system is organized and centralized to effect the greatest efficiency. Light repairs are made in garages under the supervision of truck-center administrative officers. Major repairs, overhaul and salvage are conducted at central shops and depots. Service and fuel stations are connected by telephone through the offices of the chief dispatcher to facilitate timely service and to supply information for the control of the entire system.

A paper on the Engineering Aspects of Traffic was read by W. P. Eno in which he called attention to some of the material on the control of traffic that has been published under his direction. He stated that he was not in favor of the present plan of regulating traffic by towers as employed on Fifth Avenue in New York City. He favored the rotary system of traffic control at congested centers and cited the arrangement at Columbus Circle in New York City as an outstanding example of the success of this method. The papers were followed by a very active discussion of specific examples of traffic congestion in some of the larger cities.

The next meeting of the Washington Section will be held on Feb. 2 at the Cosmos Club Lecture Hall starting at 8 o'clock. George W. Lewis, executive officer of the National Advisory Committee for Aeronautics, will speak on Research in Aeronautics. His lecture will be illustrated with lantern slides and motion pictures, the latter showing the recent glider competition in France. A second paper will be presented by Lieut. B. G. Leighton who is in charge of the aeronautic engine development of the Navy. The title of his paper will be Recent Developments in Aircraft Powerplants in the Navy. It will include a resume of the lessons learned from the recent Pulitzer Race and the result of the Navy's adoption of a 300-hr. test for aircraft engines and its effect on recent engine design. He will also touch on the Navy's experience with special fuels for high-compression engines.

DETERMINING VARNISH QUALITIES

Demonstration of Laboratory Procedure Supplements Presentation of Paper

The first body engineering session was held on the afternoon of Tuesday, Jan. 9, George W. Kerr presiding. Papers on Automobile Finishing-Varnish, by L. Valentine Pulsifer, and on the Needless Hardwood Lumber Waste, by Frederick F. Murray, furnished the material for discussion.

Mr. Pulsifer's paper was accompanied by a demonstration of laboratory tests. After explaining the various qualities that are included under the terms shop qualities and service qualities, with the aid of members of his staff he showed how they might be determined experimentally. First showing how two varnishes might be compared with regard to their working, flowing and setting abilities, tests then were made to indicate how the viscosity, elasticity, moisture and alkali resistance, film-factor and service-durability rating were ascertained. The Kauri reduction-test for determining the gum-oil ratio upon which the elasticity of the varnish depends was described in detail.

Replying to a question of S. G. Tilden in the discussion of the paper, Mr. Pulsifer said that body polishes not only do not increase the life of a varnish but frequently contain abrasive material that is destructive. Waxing increases the varnish, but to put on a new finish the old surface must first be removed. Chairman Kerr brought out the point that a certain amount of moisture in the drying room is desirable to avoid too rapid setting of the varnish, usually a difference of about 20 deg. between the wet and dry bulbs of the thermometer; with enforced drying this might reach 80 or 90. In answer to F. E. McCleary, Mr. Pulsifer stated that on account of the number of variables the use of the violet ray thus far was only experimental. Answering Herbert Chase, he said it was possible to produce a durable finish that is not lustrous, but that by adding an excessive amount of pigment and by rubbing-down a varnish such as a chassis varnish it might be brought to a dull finish, the durability would depend on the quality of the materials used. To another query of Mr. McCleary, he re-

plied that toughness rather than hardness determines the resistance to abrasion. The results of too quick drying and too great hardness are too little understood; the durability would be doubled if more time were allowed in the application of the varnish. In replying to Mr. Shidle, Mr. Pulsifer said that price does not follow the rating of the varnish on the durability-rating chart. Comparing varnishes *D* and *A* on the chart, the ratio of durability is 6 to 1, whereas the price-ratio is about 2 to 1. To Mr. Kerr's point regarding rust he replied that rusting under the varnish is due to insufficient cleaning and to rust that has not been removed before the primer was applied. To Mr. Kendall's question, Mr. Pulsifer stated that distilled water has more effect in turning varnish white than has salt water. Although salt acts as an abrasive, it is the dew and fog that cause the most damage on ships.

SIMPLIFIED HARDWOOD SPECIFICATIONS

Revision of Existing Obsolete Grading Methods Urged to Prevent Waste

Mr. Murray by lantern-slides showed the process of obtaining hardwood lumber, following its course from the cutting of the tree to the finished product. The views included the felling of ash, oak and gum trees; the manner of transporting the logs to the sawmills by oxen, mules, tractors and steam trains; the methods of handling the logs at the mill; quartersawing; cutting veneer; and loading the lumber on the cars. The only way, he said, in which to get lumber into its proper classification is by grade specifications. Grade structures were written before the automotive industry came into existence. No. 1 top grade is composed of firsts and seconds, but there are not enough firsts and seconds to go round. Grades, therefore, must be drawn in terms of certain cut-up sizes. Specifications are written in terms of secondary defects but without regard to how the defects appear in the board. The idea that a board with two defects is only one-half as valuable as a board with only one defect is erroneous. But a No. 2 board is very desirable, while a No. 3 board is suitable for toys, and so on. By defining boards in terms of the cut-up sizes 15 or 20 per cent can be saved; and 5 per cent would be worthwhile, because of the diminishing supply and the increasing demand. The specifications should take a certain cut as a minimum and increase 1 in. at a time up to a maximum of 96 in. The question resolves itself into a tabulation of cut-up sizes. A special committee should classify cars and in the classification include the various makes and body styles, so that the committee could supply a list that would represent the automotive field. In the tabulation of the cut there will be shown a remarkable standardization of size. Getting the data is a greater task than reviewing the requirements, and the proper way of doing so would have to be worked-out. The American specifications are the greatest movement ever sponsored by the Department of Commerce. A good plan to conserve hardwood would be for Congress to prohibit the shipping of lumber except to automotive and farm implement industries, and not to the building trades. In Memphis a movement started to use 2x4-in pieces for building, to secure a better market, as more defects are allowed. The producers also look to the railroads to use the gum tie. By treating the ties immediately after being cut the incipient stages of decay are controlled and the mechanical wear and resistance to rot are increased.

CUTTING CLOSED-BODY PRODUCTION COSTS

Wire Mesh, Buckram and Leather Substitutes Utilized Instead of Sheet Metal

At the second body engineering session, held on Wednesday, Jan. 10, with G. E. Goddard presiding, the papers were by George J. Mercer, on Cheaper Closed-Body Construction, and by J. B. Davis, on the Testing of Leather Substitutes and Top Material.

Mr. Mercer called attention to the fact that the estimated output of closed cars for 1922 is 635,000, which is about double that of 1921 and nearly three times that of 1919; and that the ratio of closed to open bodies is constantly increasing. Commencing with the all-wood body similar to that of a carriage, first aluminum and later sheet-steel were substituted for the panels, then the all-steel body was introduced. The last named has the advantage that when assembled it can be bake-enameled, which increases the durability and saves time. But this necessitates the continuing of one model for a long time and also limits the finish to black. Other methods of reducing the cost of production include smaller bodies of simpler design with straighter lines and rounded corners, fewer moldings, duplicate glass-sizes, simpler door-hinges and trimmings, fabric roofs and improved painting methods. A recent effort at reducing the cost is by constructing the body in sections and shipping it in the knockdown shape. A radical innovation is the covering of the body entirely with fabric over a foundation of wire and buckram which is fastened to the conventional wood framing.

To those who are familiar with the California top the idea is not new and the durability is well known. The fabric body has the advantage of using a foundation that is cheaper, lighter, more easily and quickly applied, yet is of sufficient rigidity to retain its shape when molded. In appearance it is said to resemble the landau leather that has always added a satisfying finish to high-priced cars. Two years of service in all kinds of weather has shown the finish to have lasting qualities and brightening it requires nothing more than the friction of a soft cloth; its elasticity is sufficient to absorb shocks, while at the same time its non-conductance of heat renders it warm in winter and cool in summer. The weight is said to be ¾ lb. per sq. ft. as compared with ⅞ lb. for aluminum and 1½ lb. for steel. The flat cost of the covering and the foundation material on the sample body described in the paper was 26 cents per sq. ft. Aluminum costs 30 cents per sq. ft. and steel 7 cents, not including the stamping and hammer costs as well as the finishing and painting. The work of designing, millwork and framing is the same as for an ordinary body but a great saving is to be made in finishing; two men finished both the interior and exterior of a car in 2 weeks. No such care was required to protect the outer surface, which was finished first, as would have been necessary had the surface been painted. Even when shipped the body was not covered. As enameling is a quicker operation than painting, the fabric-covered body will effect a saving in time of from 5 to 11 days according to the quality of the work considered. Imitation leather, more properly called leather-cloth, heretofore has been made only with a semi-dull finish, but the high luster of the new process offers an additional attractive feature. Summing up, the actual benefits to be derived from a fabric-covered body are that it is of lighter weight, is more quickly fabricated, is

sound-proof and suitable for all seasons, has unequalled flexibility of construction that will allow the more expensive shapes to be made cheaply, and at the same time possesses a finish, design and attractiveness comparable to bodies made with the customary materials.

About 80 persons were present during the reading of Mr. Mercer's paper and the interest that it aroused was indicated by a lively discussion which was taken part in by Messrs. E. W. M. Bailey, Chairman Goddard, G. W. Kerr, L. C. Hill, Edward Wotton, P. W. Steinbeck, Alvin Hunsicker, H. B. Day and L. L. Williams. Replying to questions, Mr. Mercer explained that the forming of the wire on the body was done by hand and that the upper round back-corner, which was expected to give trouble, was found to be surprisingly easy. Usually, he said, it would be better to put the buckram on a form and let it dry before installing it, especially in mass production. Regarding the necessity of making the wood-frame structure stronger at the joints than when metal panels are used, he had decided that it would make no difference except, possibly, in special cases.

Three-point engine suspension gives greater flexibility of the chassis but has a tendency to distort the frame; the fabric construction would make the body more uniformly flexible rather than localize this distortion. The tendency of leather to stretch and sag is not apparent in leather cloth on account of its being stretched and shrunk in much the same manner as paper on a drafting-board. Two years of hard service has failed to show any deterioration. Mr. Warren emphasized the difference between the construction of a passenger car and a motor-coach, the latter requiring much greater strength and stiffness on account of the greater width between the supports, but if the coach were to run on pneumatic tires at a high rate of speed such as might be demanded on interurban service the question of flexibility would be important. With regard to possible bulging between the moldings and on the sidesweeps and turn-under, no trouble was experienced as the material is fastened under the molding before the molding is applied. The surface of the leather cloth is not soft and flexible but it is stretched tightly over a firm foundation. No wadding is required because the surface is built full before the material is put on. With regard to the patent aspect Mr. Mercer's understanding was that there would be no restrictive methods used to prevent any body-builder from availing himself of this form of construction but that Mr. Childs would undoubtedly protect himself in some way and endeavor to reimburse himself for the money he had spent in conducting 2½ years of experimental work.

Chairman Goddard believed the all-steel body would come eventually, because when produced in a sufficient quantity the cost is less; it can be pressed out of the sheet, electrically welded, assembled and enameled in somewhat over a day of actual time, whereas a wooden sedan body requires about 106 days, including 18 or 19 for painting. To demonstrate whether a stiffer frame will be required to prevent the joints loosening up in service a test car will be put on the road in February and tried out on hard roads in bad weather. Patching can be made as easily as with wood or metal panels. If the modern method of building were used, replacing a section would be easier than repairing.

The use of fabric panels in buses was said by Mr. Wotten to be adequate for anything short of a collision, but that excessive distortion would have to be taken care of by additional braces.

To E. W. M. Bailey's question, Mr. Mercer replied that the elasticity of the fabric appeared to be one of its most attractive features, for every closed body must twist; the frame instead of being made heavier should be made lighter with heavier joints. G. W. Kerr stated that he had made experiments in which a chassis had been twisted 1½ in. He believed the tendency was in the direction of the unbendable and untwistable frame. Even with the stiffest bodies the glass frequently breaks because of a sudden twist. He thought that sagging was caused not by stretching but by shrinking. Leather tops on carriages always used to shrink. The soft roof has proved satisfactory in deadening sound. In the old days the green hide was stretched over the roof and down the sides and the back; it was then painted, rough-stuffed, varnished and finished, as if it were wood. Alvin Hunsicker compared the fabric to that of which a Van Heusen collar is made, two fabrics being constructed in a different way and put together with waterproof cement, so that they cannot stretch. Referring to Mr. Kerr's remarks on the stiffness of the chassis, Chairman Goddard remarked that there was no doubt that the frame was becoming stiffer. There should be no spring in the frame; all the flexibility should be in the springs. These are usually made to carry correctly three-quarters of the passenger load; that is, a five-passenger body will ride under average conditions with three and one-half to four passengers. A check that he had made, which was confirmed by E. S. Jordan, showed that during a period of 6 months, as observed on street corners, the average number of passengers carried per car was 1.6. He noted that the Hotchkiss frame referred to by Mr. Kerr not only had cross bracing but was built much heavier than was necessary and that the intersection of the four members of the cross was drilled with holes, evidently for the purpose of mounting a gun. L. C. Hill called attention to the recent canvass of the National Automobile Chamber of Commerce which showed that 60 per cent of the users of cars want closed and 40 per cent want open bodies; methods of cutting down the cost of closed bodies, therefore, should be considered.

Mr. Mercer, replying to a question on the proper method of applying the molding, said that the best way seemed to be to apply a separate panel with a piping, which is made by the fabric being brought over a reed. The piping is ¼ in. in diameter and is fastened to the panel before it is inserted. The panel is pushed in and covers the opening. Mr. Bailey said that he had used half-oval drawn-steel molding with stubby-headed nails spot-welded on the flat side, instead of the lead-filled molding that Mr. Mercer considered too expensive. Being of steel, high baked enamel could be used and the steel could be dented without spoiling the enamel.

Mr. Kerr remarked that while fabric would eliminate the drumming noises that come from the roof, the roof was not the source of all noise; that he had stopped "booming" by placing his hand on the glass on each side, the "booming" being caused by the fact that the vibration of the glass and that of the chassis were in synchronism. Mr. Hill suggested that the rumble had been taken out of one series of Packard cars by adding 3 in. to the tail pipe of the muffler. Mr. Goddard added that lengthening the pipe or increasing its size steps the vibration up to a higher mile-per-hour speed and that, while it is still there, it is not so noticeable. The other vibrations due to the engine must be overcome by sound-proofing. Some of the noise is transmitted through the body-front structure and appears more in the front section of the roof. This frequently can be obviated by

padding the front portion between the first two ribs. Mr. Mercer replied that he had been told that morning by a body-builder that the trouble had been obviated by changing the method of bolting to the frame, by moving the first bolt, which had previously been put close up to the dash, back 9 or 10 in. Chairman Goddard thought that the steel dash, which is in almost universal use, being located at a point where the three-point support on the chassis has its effect, acted as a sounding-board and was responsible for about half the noise in the body that is not in the roof. He added that outside of increased quantity production the principal directions in which cost could be reduced lie in the use of some new material such as fabric by which the body could be covered faster than it could be painted; the study of the sequence of the various trimming and assembling units so that they shall not get in one another's way; and the study of demountable construction. Another speaker declared that, in his opinion, the only way to cut down the cost of bodies, outside of those custom-made, was by making them simpler, omitting all the frills and dispensing with as many moldings as possible. Chairman Goddard interpolated the suggestion that members should endeavor to avoid the use of the terms "pleasure car" and "sport model" and lay stress on the word "phaeton," which was approved at the meeting of the Standards Committee that was held in New York City in January of last year, to denote what has been known as "touring car."

Replying to Mr. Hill's query as to the reception of artificial leather by the public, Chairman Goddard said that the difference in price between a sedan trimmed in mohair velvet, and painted and varnished on the outside, and the black-enameled steel body-construction, trimmed in Spanish leather on the cushions and backs and imitation leather on the sides, made comparison difficult; that it was a question of utility; that the use of mohair velvet and of enamel gives the car a higher second-hand value. Mr. Day stated that he had the first California top made; that he had a car on which fabric had been used and had driven it over 60,000 miles, including a trip from California to Philadelphia and back, over very bad roads in Arizona and California; that it had been in the desert, in the snow, had been exposed to salt water and to the sun, in a climate where there is 8 or 9 months of heat, and that it looks very nearly as good today as when it was turned out. Mr. Williams inquired why the Society did not decide what to do to cheapen construction. He asked why mortised joints are necessary, instead of half-lapping them and sinking in a screw; why glue is used for certain parts rather than a screw; why a door is employed that laps three times and a weather strip is then put inside it; why not cut out the breaker-strip on the wood-frame door and lap the panel over the door; why specify silver plate-glass; why use five screws on a weather-strip when two or three would be sufficient; why use nails 1½ in. apart on a panel when the panel could be torn off if they were 4 in. apart. Mr. Steinbeck replied that such questions had been answered by Ford bodies, but Ford bodies could not be put on a Lincoln, Packard or Rolls Royce car; that different qualities are required from the body engineer as well as the chassis engineer. Chairman Goddard, in closing the discussion, said that the whole matter went back to quantity production; that operations can be conducted more simply and more cheaply by increasing the equipment but that the cost of the increased equipment of jigs, tools, fixtures, dies, forms and similar appliances required could be cared for only by spreading it over a sufficiently large quantity of completed bodies.

COOPERATION ANNUAL DINNER KEYNOTE

Between Fuel and Automotive Industries and Railroads and the Motor Truck

On Thursday evening, Jan. 11, 977 members and their guests attended the Annual Dinner of the Society in the ballroom of the Hotel Pennsylvania. Retiring President B. B. Bachman presided. With him at the speakers' table were prominent representatives of the various branches of the industry. Each table seated 10 persons but so large was the crowd that the use of both the main floor and the balcony was required and even then all available space was occupied. A musical program was rendered throughout the dinner by the popular Vincent Lopez orchestra of the hotel.

President Bachman questioned the advisability of holding future meetings of the Society during the week of the Automobile Show, because the number of counter-attractions at that time affected the attendance at the technical sessions, and cited the recent Production meeting in Detroit, which was notable on account of the large attendance and the value of the proceedings. After expressing his appreciation of the support that had been given him during his term of office by the members of the Society and bespeaking a continuation of it in behalf of his successor, President-Elect Alden, he introduced C. F. Kettering, who acted as toastmaster.

Mr. Kettering recalled the fact that at the dinner a year ago the subject of the address was, Has Business Really Turned the Corner?; that a number of predictions had been made for the coming year, most of which had come true; and that red paint and nickel-plating had again come into their own; that when Henry Ford was asked by Will Rogers at how low a price he could afford to sell his cars, Ford was quoted as saying that if he were to give away the car in a few months the sale of supply parts to replace those lost would pay for the car; that Ford was the only one to acknowledge what the rest leave to their customers to find out. Styles in motor cars, Mr. Ketting said, are exactly opposite to the styles in women's dress. It used to be the case that when a car would not start it was the fault of the starter; now it is the spark-plug, a set of which can be bought for $4. The fuel and the motor car industries have finally got together, the petroleum industry having recognized at last that the Society had in it some very good men; at a recent meeting a resolution was drawn up to the effect that the public will continue to use such fuel as the producers care to produce at such prices as they care to charge; that the engineers will build such engines as they please, which will give such mileage as they do notwithstanding the claims of the advertising manager.

The keynote of the address of Elisha Lee, Vice-President of the Pennsylvania Railroad Co., the principal speaker of the evening, was cooperation. On the principle of "live and let live," he pleaded for a unification of transportation effort and a division of the long-haul and the short-haul business, leaving the former to the railroads because they can handle it more efficiently, and the latter to the motor trucks, because they are peculiarly adapted to store-door collection and delivery. He believed that better results would be obtained by building roads through undeveloped sections and putting those sections in connection with the main arteries of transportation than by paralleling existing systems and dividing up the business that is barely sufficient to maintain the systems in operation at present. As an instance of over-development he cited two cities of the Middle West,

already connected by two railroads and by interurban electric lines, that were further joined by concrete roads over which several motor-truck lines are operating, thereby giving these cities greater transportation facilities than those enjoyed by New York City and Philadelphia, in the Country's most densely populated section. He said that if the volume of traffic were found insufficient to support both rail and motorbus lines it would seem only fair that the people should decide which form of service they desire and abandon the other; that in some localities the railroads were forced to run accommodation trains which did not pay half the cost of operation.

Mr. Lee did not believe that motor vehicles and concrete highways would erase the railroads from the map, as some persons have been led to believe, but that they would add greatly to the utility and efficiency of the railroads by rounding-out and completing the service, relieving the railroads of certain forms of burdensome and costly service that can be made attractively profitable to the motor vehicle, whose function is not to do what the railroads are equipped to do successfully but to do what the railroads are unable to do or to do only with difficulty. Although there are approximately 12,000,000 motor vehicles in the United States, the freight traffic of the railroads has nearly tripled since 1900. The question is one of wholesaling and retailing, the railroads handling best the mass transportation over considerable distances and the motor truck the freight pick-up work in the larger cities in less-than-carload lots. Coordination of this kind would be a vast improvement over the haphazard facilities usually at the disposal of shippers and consignees, who thus would have the benefit of a semi-express service. Whether terminal trucking should be done by the railroads or independently would require careful study, but the added complication of management and possible restrictive legislation seem to favor independent operation. The radius of the economic operation of motor trucks around a large city probably would be about 25 miles for less-than-carload lots; for longer distances greater efficiency might be obtained by the use of trucks for collection and delivery and the railroad for the intermediate line-haul. The use of motor-driven rail cars for passenger service on branch lines was, he said, a problem for the automotive engineer. The railroads were carefully studying every new design brought out but thus far none had been produced that could fully and satisfactorily fulfill the requirements. The primary purpose in both railroad and motor truck-transportation should be development along sane and sensible lines and the rendering of the maximum service of which each is capable.

Toastmaster Kettering, in introducing Herbert W. Alden, assured the members that the new president-elect, having carried the burdens of the industry for so long on his axles, could be counted on to carry those of the Society in an equally effective and satisfactory manner.

The new president outlined concisely some of the plans of the Society for the coming year. He expressed his gratification at the response of members who had been asked to serve on various committees, saying that out of 42 to whom requests had been sent only one had been unable to accept. Agreeing with Mr. Bachman, he believed that the technical sessions should be held at some time and place other than that of the annual automobile show; also that too much emphasis had been placed on the engineering side of the work and that efforts should be made to bring the engineering and production sections into closer relation. He announced that H. M. Crane had consented to continue for another year as Chairman of the Research Committee, and that B. B. Bachman would serve as Chairman of the Highways Committee. Special attention will be given to strengthening the local Sections of the Society.

USE OF LEATHER CLOTH ADVOCATED

Methods Employed Commercially for Testing Automobile Materials Outlined

J. B. Davis, in his paper on the Testing of Leather Substitutes and Top Materials, after a short historical introduction, discussed the various qualities of fabrics, and of leather cloth in particular, that should be embodied in specifications, and described the methods of determining these qualities by test. He showed that leather cloth was first manufactured in England in 1800 and in this Country in 1850. From a beginning in which a few hundred yards per day was considered a heavy production, the output has increased steadily, reaching in 1922 a total of 50,000,000 yd. Among its uses are one-man tops, curtains, upholstery, linings, gimps, welting, truck covers and lining, mudcaps, spring covers, and the curtains and covers of truck cabs. Other fabrics in use include muslin, drill, twill, sateen, moleskin and duck. The non-scratchable feature of the patent-leather finish gives to leather cloth many advantages over a painted and varnished steel surface and makes it particularly desirable in body construction. As the amount used on each car is small, quality is more important than price and the most desirable attributes are durability and appearance. With regard to appearance, the luster, smoothness, softness, finish and color must be considered. The desirability of other fabrics for specific purposes is judged by the weave, construction, thread-count, weight, and the like.

By lantern-slides the various pieces of laboratory apparatus were shown and the methods of conducting the several tests were described in detail. These tests covered the composition of the material; the uniformity of its weight; its resistance to wear as determined by rubbing; tensile and bonding strength; resistance to stretch and puncture; thickness; toughness and adhesion of the coating; resistance to water, shrinkage, fire, and heat; and the cleansability and resistance to gasoline. Other slides showed the effects of natural and artificial aging and of exposure, on water resistance, flexibility and toughness; the variations of skin properties, and the checking of the uniformity of pigments and fillers.

In the short time that remained for the discussion, which was participated in by G. W. Kerr, H. C. Mougey and C. M. Manly, Mr. Kerr brought out the point as to whether tests of uncoated fabrics from different makers did not show a difference in strength, even though the fabric might have the same characteristics of weave, weight and thread-count. This was answered in the affirmative, and was said to be due to the length of the fiber of the cotton, amount of twist and other factors. Replying to the query of Mr. Mougey, Mr. Davis stated that by combining the action of water and wind with that of a mercury-arc light, which reproduces the actinic rays of the sun, in a small cabinet, aging of material might be accomplished in a few days that formerly took from 6 months to 1 year. Mr. Manly added that in his experience during the war there was a great difference in strength between long and short-staple cotton; that twisting, mercerizing and different chemical treatments had great difference in their effect; that the simplest way to determine the effect of the number of twists is to subject the sample to test rather than to follow the course of the cotton through the mill.

Applicants *for* Membership

The applications for membership received between Dec. 15, 1922 and Jan. 15, 1923, are given below. The members of the Society are urged to send any pertinent information **with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.**

ALM, BRUNO, designer, Yellow Coach Mfg. Co., *Chicago.*

ALMEN, J. O., chief engineer, Almen Motors, Inc., *Seattle, Wash.*

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BROOKS, CAPT. JOSEPH L., Camp Holabird, *Baltimore.*

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HILL, JAMES H., University Garage Repair Shop, *Evanston, Ill.*

HOLOWAY, PERCIE U., estimator and service salesman, Donovan Motor Car Co., *Boston.*

JOHN, WILLIAM EDGAR, vice-president, Hall Wheel Corporation, *Philadelphia.*

JORDAN, EDWARD S., president, Jordan Motor Car Corporation, *Cleveland.*

KEEGIN, CURTIS W., district manager, Cincinnati Ball Crank Co., *Cincinnati.*

KEISER, KARL W., student, University of Minnesota, *Minneapolis.*

KING, W. GRANT, president, King Sewing Machine Co., *Buffalo.*

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MARSH, W. R., superintendent, Locomobile Co. of America, *Chicago.*

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MIDDLEKAUF, EDISON B., automotive purchasing agent, Texas Co., *New York City.*

OSMOND, CHARLES H., chemical engineer, Atlantic Refining Co., *Philadelphia.*

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PIERSON, D. M., assistant experimental engineer, Dodge Bros., *Detroit.*

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ZAHOUR, R. L., student, Case School of Applied Science, *Cleveland.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Dec. 9, 1922 and Jan. 10, 1923. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member; (E S) Enrolled Student.

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